

## SECTION D - CONTROLS

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## SECTION D - CONTROLS

## I. INTRODUCTION

Water storage reservoirs require outflow control to satisfy downstream water needs. The control system should be adjustable to a degree that waste is minimized, and should be able to retain its setting.

The most common method of reservoir water control is the slide gate operated by means of a handwheel or geared crank lift. Support for the lift and the stem is provided by concrete pedestals set in the embankment.

The hydraulic cylinder has been used a long time for slide gate control in water treatment plants. Recent advances in materials and production technology made the hydraulic system adaptable to many applications in earth dams.

The Interchangeable Series of hydraulic cylinders of the Joint Industry Conference (JIC), available from several manufacturers, includes a wide range of sizes. A pressure range of 2000 psi operating, or 3000 psi non-shock, a variety of mounting styles of certain standard mounting dimensions, and several features that fill the requirements of Service installations are readily available.

## II. DESCRIPTION OF THE SYSTEMS

A. Mechanical

The mechanical system develops its lifting force from the principal of the screw. A handwheel or gear reduction unit, see Figure C-1, converts the effort of the operator on the handle to torque on the lift nut and thrust on the stem and the gate slide. The reaction to this thrust is taken by the mass of the gate lift pedestal and the embankment in which it is embedded.

The thrust is transmitted to the gate by the stem, held in alignment by guides that are in turn secured to gate stem pedestals set in the embankment. If the basic structure is all concrete, the lift, guides, and gate frame are secured to it and all reactions are transmitted through it. Some manufacturers list a single maximum guide spacing for each stem size. The spacings shown on Figure D-1 are set by the allowable combined stresses in the stem material caused by the axial loading and bending from stem weight and eccentricity. Guides have several inches of vertical adjustment for correcting stem alignment as the embankment settles. Provisions for lateral adjustment are also included.

A variation of this system, the non-rising stem model is illustrated in Figure C-1, in which the lift nut is mounted in the gate slide and moves up or down as the stem is turned at the control station. Thrust is taken by a bearing on the gate frame yoke and the length of stem from the control station to the frame transmits torque only. In this variation the handwheel or gear unit is keyed to the stem.

In areas where freezing is a regular winter occurrence, it is necessary to encase the stem and bury it to avoid its being bound in ice or forced out of alignment. The encasement consists of a pipe filled with oil, equipped with seals at each end to allow the stem to slide freely through while retaining the oil. Carbon steel stem is used throughout the encasement length except that portion which moves through the seals. To maintain an effective seal, the section of stem that moves through the seal must remain corrosion-free and smooth, and is made of bronze\* or stainless steel. Even though tables indicate that a smaller stem of stainless steel could replace the regular size of carbon steel, it is not practical (considering the necessary adaptations) to change the size for one section of the stem.

If it is necessary to use a bolted splice instead of the riveted one shown in the standard drawing, it will also be necessary to increase the size of encasement pipe and the quantity of oil.

In some cases, a "T" has been used in the encasement near the weather seal for addition of oil. This detail has not been shown on the standard drawing since the weather seal can be loosened for the infrequent need for more oil.

There are instances where the upper end of a stem encasement has been cast into the concrete of the lift pedestal. Designs in this Section consider that no thrust is to be carried in the encasement pipe. The supporting angle at the lift pedestal serves only to aid alignment and to relieve the packing gland of supporting the encasement weight. Any repair to lift, stem or gate that will require the disassembly of the encasement will show the advantage of independent construction.

#### B. Hydraulic

The muscle of the hydraulic system is the double-acting hydraulic cylinder that uses oil under pressure (up to 3000 psi) to move the piston and the attached gate slide. Pressure is developed by a hand or power operated pump at the control station and developed by a hand or power operated pump at the

\* High cost of bronze makes stainless a more economical choice.

control station and directed through piping to the opening or closing end of the cylinder by a 4-way valve. Typical Hydraulic Control Applications, Figure D-20, show variations in gate orientation that can be obtained without the usual alignment and access problems. The control station can be placed at any convenient location within economic limits. Components are:

1. Cylinder

As stated earlier, a cylinder selected from the JIC Interchangeable Series can be supplied by several manufacturers. Certain options are necessary to meet the special needs of Service installations. Stainless steel piston rods are essential for submerged location. The exterior surfaces of the cylinder should have corrosion protection of chrome, cadmium plating or an epoxy enamel.

Packings for the piston and the rod gland must have maximum sealing characteristics to enable the piston to hold the gate in a raised position over a period of several days. A multiple-v type seal or a new cup type with an O-ring filler will give near zero leakage. The rod gland of these cylinders is replaceable without disassembling the whole cylinder.

2. Pump

Pressure to operate the cylinder is developed by a pump powered by hand, electric motor, or internal-combustion engine. There are several variations of pumps available that meet the minimum requirement for pressure. Hand pumps may be single or double acting, with dual pistons, adjustable leverage arrangements, or self-regulating devices to vary the flow rate when pressure requirements change. Rotary pumps for powered operation are usually of the gear, vane, or axial-piston type, listed in the ascending order of pressure capability.

3. Reservoir

An oil reservoir is necessary and should be located to keep the pump intake full at all times. Minimum reservoir capacity should be sufficient to contain the oil displaced by the cylinder piston rod when in the retracted (upper) position.

4. Control Valve

A 4-way valve directs the flow of oil from the pump to the opening or closing side of the cylinder piston and allows

return flow of oil to the reservoir. This valve may be a rotary or a spool type, either one further qualified as closed or open center.

A rotary-type selector valve effectively stops any back flow from the cylinder while in a neutral position, and maintains the set position of the gate.

The spool-type valve, commonly used on hydraulic equipment, has internal leakage inherent with its design and can allow the gate to creep closed over a period of time unless supplemented by a pilot-operated check valve at the cylinder.

For hand-operated pump installations, a closed center valve is recommended. It will permit no through flow when the valve is in a neutral position.

For power-operated systems, an open center valve is necessary to permit free return flow to the reservoir when the pump is idling.

## 5. Hydraulic Lines

Pipe lines connecting the control station and the cylinder at the gate should be either stainless steel tubing or a rubber or synthetic hose suitable for medium or high pressure. In most cases they will be buried in the face of the embankment within a conduit of galvanized, fiber, or plastic pipe for external protection. Hose fittings should be corrosion resistant and of the permanent type, factory installed.

## 6. Hydraulic Fluid

The hydraulic fluid is most commonly a mineral base oil with additives to maintain chemical stability, lubricating qualities, and anti-corrosion characteristics. Its viscosity should not exceed 3000 SSU (Saybolt second units) at the lowest expected operating temperature. This is to assure oil flow to the pump and lubrication during cold starting. This is most important to a powered unit.

However, viscosity is an important factor in line loss due to friction and so affects hand units as well:

## III. COMPARISON

A choice between mechanical and hydraulic controls can be made by evaluating the advantages of the conditions for each system. For

the usual situation, costs have been compared and the black dashed line on Figure D-1 represents the combination of head and gate size for which costs are about equal. Cost studies favor the mechanical system below the line and hydraulic above. The cost comparison assumes no stem is used in the hydraulic system and the cylinder is located at the gate.

The advantages and disadvantages of the two control systems to be evaluated for a particular installation are:

#### A. Mechanical System

##### 1. Advantages

Simplicity of design. Economy in many sizes of gate-frame-lift units. Gates, lifts, and accessories are available from the same manufacturer. This factor is of more importance when it is necessary to place some responsibility for design with a subcontractor or supplier. Positive indication of the gate opening can be obtained. Portable gasoline or electric drives are available.

##### 2. Disadvantages

The system needs careful alignment of all components. It is subject to misalignment with any settlement of the embankment. Broken slopes need special equipment, such as universal joints. Installations on vertical risers need access facilities such as catwalk or boat. Stop nuts are the only safety devices on standard units. Excess force on the handwheel or crank can damage the gate or the structure. Powered and automatic units with all safety devices are quite expensive. Labor efficiency is about 20%.

#### B. Hydraulic System

##### 1. Advantages

The gate may be oriented in any position without alignment with the control station. Broken slopes are no problem. The control station can be located anywhere (such as at the downstream measuring device) that can be reached with flexible conduit; convenience can be balanced with economy. Controls are easily adapted to power, remote, and automatic control. A multiple gate installation can be placed more compactly to use a common pump and power source. This system has an economic advantage in may slope installations or on risers that would otherwise require access facilities. Safety devices are easily incorporated into this system. Parts and service are available from local distributors. Labor efficiency is about 70%.

## 2. Disadvantages

There is a possibility of oil leakage. Positive indication of the gate opening is difficult. An approximation can be made with an oil level sight gage on the reservoir. Low temperatures can affect the speed of operation.

## C. Labor Requirement

As a means of explaining and illustrating some of the principles involved in labor appraisal, the following example and explanation has been included.

Given: A 30" x 30" gate under 40' differential head.

Determine: Work required to open the gate by mechanical or hydraulic lift.

Solution:

The force required to move the gate is given by equation

$$F = fwhA + G$$

where:

F = total force required at the gate (lbs)  
 f = coefficient of static friction between gate slide and seat  
 w = density of water (62.4 lb/cu ft)  
 h = unbalanced head of water on center of gate (ft)  
 A = area of gate, including 1 inch seats (sq ft)  
 G = weight of gate slide in air (lbs)

For a mechanical lift one manufacturer recommends a value of  $f = 0.3$  for operation (relying on a momentary overload to overcome static friction,  $f = 0.7$ ). The average weight of a 30" x 30" gate is 450 lbs.

Substituting

$$F = 0.3 (62.5)(40)(2.67)^2 + 450 = 5790 \text{ lbs}$$

The manufacturer's selection is a geared crank lift with a 4 to 1 ratio and a stem diameter of 2 inches. The rating of the lift lists a capacity of 7540 lbs with 25 lb force on the crank, and 16 turns required per inch of gate movement. Efficiency of the lift is included in this catalogue rating.

Since only 5790 lbs are needed, the required force ( $F_R$ ) will be proportional.

$$F_R = \frac{5790}{7540} \times 25 = 19 \text{ lbs}$$

Total work is a product of force (F) and distance (D) or

$$\begin{aligned} W &= FD \\ &= F_R 2r \pi n \end{aligned}$$

where:  $W$  = total work (in-lb)  
 $F_R$  = force required on crank (lb)  
 $r$  = crank radius (inches)  
 $n$  = number of crank turns

For one inch gate movement

$$\begin{aligned} W &= (19)(15)2\pi(16) \\ &= 28,700 \text{ in-lb work input} \end{aligned}$$

For the same gate installed with a hydraulic cylinder lift the same manufacturer requires 0.7 for a friction factor. The higher force for this installation is based on the concept that the gate will seat tighter and with pulsating oil flow from a single acting pump the gate will intermittently stop and start.

$$\begin{aligned} F &= 0.7(62.5)(40)(2.67)^2 + 450 \\ &= 12,480 + 450 \\ &= 12,930 \text{ lbs} \end{aligned}$$

Chart 3, Figure D-21, gives a cylinder of 3-1/4 inch diameter with a standard piston rod. Piston area available for the opening stroke is 6.811 sq in. The pressure at less than 2000 psi is indicated by the shading but can be calculated more exactly as follows:

$$\begin{aligned} p &= \frac{F}{A} \\ &= \frac{12,930 \text{ lbs}}{6.811 \text{ in}^2} \\ &= 1900 \text{ psi} \end{aligned}$$

where:  $p$  = operating pressure (psi)  
 $F$  = total force (lbs)  
 $A$  = area of piston (sq in.)

The value of  $p$  is the pressure required at the cylinder. Losses in moving the cold oil through the tubing will require additional pressure at the pump.

Assuming a viscosity of 3000 SSU (Saybolt second units) at about  $30^{\circ}\text{F}$ , a volume of 0.1 gallon per minute will cause a pressure loss drop of 100 psi per 100 feet of  $3/8$  hose. The 40 ft head example will require about 250 ft of connecting hose.

$$\begin{aligned} p \text{ loss} &= \frac{250}{100} \times 100 \\ &= 250 \text{ psi} \end{aligned}$$

The operating pressure at the pump will then be the pressure at the cylinder + line loss, or

$$\begin{aligned} p &= 1900 + 250 \\ &= 2150 \text{ psi} \end{aligned}$$

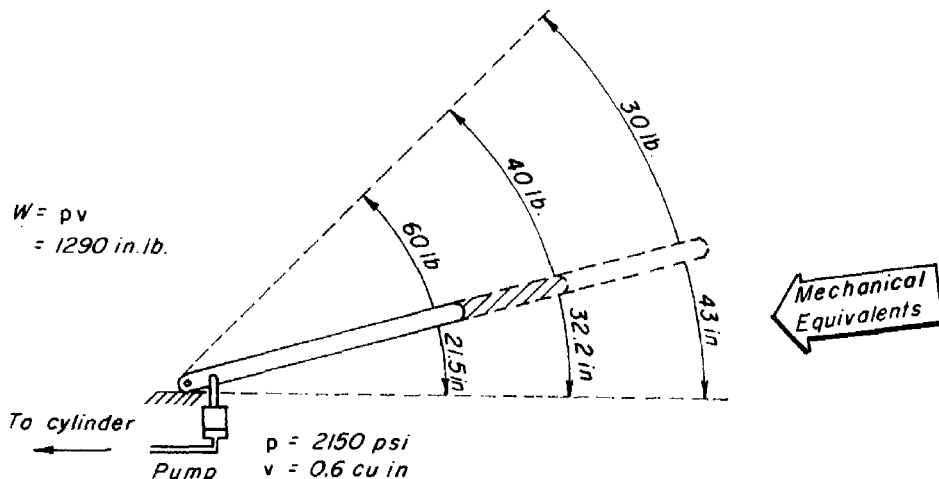
A common hand pump rated up to 3000 psi may have a displacement of about 0.6 cubic inches for a full stroke. In hydraulic terms, work ( $W$ ) is defined as a product of pressure ( $p$ ) and volume ( $v$ ).

$$W = pv$$

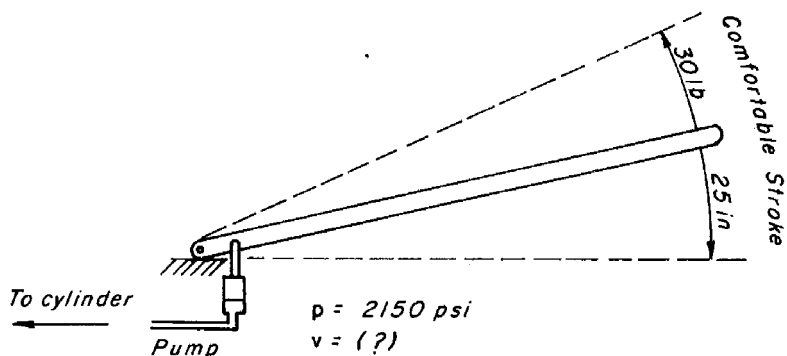
For one stroke of the example pump

$$\begin{aligned} W &= 2150 \frac{\text{lb}}{\text{in}^2} \times 0.6 \text{ in}^3 \\ &= 1290 \text{ in-lb} \end{aligned}$$

The mechanical equivalents of this amount of work are illustrated in the following sketch:



If a comfortable stroke is assumed at 30 pounds through 25 inches, the useful piston displacement will be found by reversing the above process.



Hydraulic Equivalent  
for reasonable input

$$v = \frac{W_1}{p} = \frac{FD}{p}$$

$$\begin{aligned} v &= \frac{30 \text{ lb} \times 25 \text{ in}}{2150 \frac{\text{lb}}{\text{in}^2}} \\ &= \frac{750}{2150} \text{ in}^3 \\ &= 0.349 \text{ in}^3 \end{aligned}$$

where  $W_1$  = force applied X distance (per stroke)

The number of strokes required to move the gate one inch is:

$$\begin{aligned} n &= \frac{A}{v} \\ &= \frac{6.811 \text{ in}^3/\text{in}}{.349 \text{ in}^3} \\ &= \frac{19.5 \text{ strokes}}{\text{inch}} \end{aligned}$$

$n$  = number of pump handle strokes

$A$  = piston area or volume per inch of cylinder  
piston movement

$v$  = useful pump piston displacement

The work applied in moving the gate one inch

$$\begin{aligned} W &= nW_1 \\ &= 19.5 \times 750 \text{ in-lb} \\ &= 14,600 \text{ in-lb} \end{aligned}$$

For the example the mechanical lift requires 28,700 in-lb of work input to accomplish 5,790 in-lb of work output. The efficiency is the ratio.

$$\begin{aligned} \text{Eff} &= \frac{\text{work output}}{\text{work input}} \times 100 \\ &= \frac{5,790 \text{ in-lb}}{28,700 \text{ in-lb}} \times 100 \\ &= 20\% \end{aligned}$$

As calculated, considering losses due to oil flow, the hydraulic system requires 14,600 in-lb of work to accomplish 12,930 in-lb of work output efficiency for this part of the system is

$$\begin{aligned} \text{Eff} &= \frac{12,930 \text{ in-lb}}{14,600 \text{ in-lb}} \times 100 \\ &= 88\% \end{aligned}$$

The efficiency of a cylinder is about 95-98% and the pump is estimated at 85% based on a larger ratio of friction surfaces and more mechanical linkage.

The overall efficiency of the system is a product of these three, or

$$\begin{aligned} \text{Eff} &= 0.88 \times 0.95 \times 0.85 \times 100 \\ &= 71\% \end{aligned}$$

From the above there is considerable difference in labor between the two systems which will become even greater if the friction factors should be considered more nearly equal. The difference becomes significant when costs are assigned to the labor of operation

#### D. Motor Operated Controls

Power drive equipment should include the following features:

Reverse - for opening or closing the gate.

Clutch - for quick disengage especially in electric motors of portable units.

Torque limit - prevents overload when gate is seated or hits a submerged object.

Adapter - connects drive unit to lift control.

Gear reduction - proper reduction of motor speed to recommended gate shaft revolution thru the lift control device.

Drive equipment may be portable and serve several gates or may be permanently installed and suitable for outdoor operation of a single gate, as is necessary in automatic operation.

The drive equipment may be gas engine, electric, or a gas engine operated generator for an electric motor.

Manual control size and gear ratio are selected not to exceed man's capacity to turn a crank. The need for a motor to operate the controls will depend primarily on the allowable time limit for resetting the gate. Small gates would normally not require power operation. The larger gates could require motorized lifts if the gate is to be moved over its full height, however seldom will the gate be fully opened or closed against a full head at any one time. A typical irrigation season might begin with  $1/2$  of the design flow, requiring  $1/4$  opening of the gate with a full reservoir. Flow changes throughout the season require minor adjustments of the gate. At  $3/4$  way through the season, full flow might be obtained with  $3/8$  gate opening and about  $1/2$  of full head. For emergency gate closure probably not more than  $1/4$  to  $1/3$  of the effort required to move the gate for its entire diameter at full reservoir will be needed.

#### E. Power vs Manual Control Operation

Figure D-24 has been developed for calculating effort required to operate the controls. In this figure, present day manpower capability has been assessed in terms of fractional horsepower. Entering with the required force in the appropriate system (hydraulic or mechanical) move to the intersection with the desired gate travel, follow the  $45^\circ$  guide line down to the point of intersection for the limiting time for operation, move horizontally to read horsepower and intensity of physical effort.

#### IV. GATE CONTROL SELECTION PROCEDURE

Once the gate size has been determined, the selection of the gate controls is complicated and yet fairly simple. Part of the

complication lies in the variety of catalogue equipment and engineering data available from the several suppliers in the area. Reducing the number of component choices to those available from several suppliers and standardizing the appurtenances simplifies the selection procedure.

The vertical scale at the left edge of Figure D-1 will normally be the maximum head on the gate. Even with an extended pipeline on a steep slope very little additional head will be developed below the gate provided the system is vented as recommended in Figure C-5. Except for unusual situations the head on the system is measured from gate centerline to free water surface.

Two horizontal scales immediately below the body of the chart list the additional information normally required before the system can be designed. Emphasis must be placed on the fact that while the conduit size and gate size may be the same, the load is exerted over a greater area because of the gate seats. Adding 3 inches to the gate diameter will be sufficient for most gate models to allow for the extra area over which the water pressure can be applied. A word of caution: A CIRCULAR CONDUIT MAY HAVE A GATE WITH SEAT FACINGS SET IN A RECTANGULAR PATTERN THAT MATERIALLY INCREASES THE LOAD ON THE CONTROL SYSTEM. In this case, a rectangular area including gate seats should be used in calculating resisting force.

#### A. Mechanical Controls

The total load to be handled by the components of a gate control system varies with the size of gate and head of water. A series of diagonally curved lines on Figure D-1 expresses the variation of load directly into component size requirements rather than in pounds. Since the stem diameter, the lift and its pedestal are sized for this common load, their selection has been incorporated into this one figure.

##### 1. Lift Pedestal Size

The uppermost scale of Figure D-1 is divided into six zones, A thru F, representing standardized lift pedestal sizes and the range of load (gate size vs head) for which they were developed. Zone limits have been extended into the body of the figure by the solid black diagonally curved lines. Details for the lift pedestal are found on Figures D-9 thru 14 and in the Appendix, Table J-D2.

##### 2. Stem Diameter

The second scale across the top of Figure D-1 is divided into three red areas extending into the body of the figure.

These separate the figure into five zones delineating the range of load that may be handled by the stem diameters listed across the figure. The diameters have been limited to those readily available from most gate suppliers.

### 3. Lift Type

The third scale on Figure D-1 pertains to lift type. For larger gates and higher heads the load is heavy enough so that geared crank lifts are required. This zone is shown with a black background and is divided into three gear ratios. For smaller gates and heads, an operator can handle the load with a less expensive handwheel varying in size from 10" to 30" diameters listed across the scale. As the load becomes greater at the right end of the handwheel scale, ball bearings are required to reduce friction and consequently, the pull that the operator has to exert on the handwheel to move the gate. Both handwheel and geared crank lift are sized so that the maximum pull the operator has to exert is 40 lbs. A bronze lift nut will reduce friction and the required pull to about 35 lbs maximum and is recommended for those installations that require frequent gate adjustment.

### 4. Inlet Structure Size

The inlet structure size is not shown on this sheet. Its size is dependent only on the conduit. The appropriate letter designation may be found on Figure C-2.

### 5. Stem Pedestal Spacing

The diagonal line slanting upward toward the right across the chart gives recommended spacing of the gate stem supports.

#### a. Encased stems

The dimensions just above the line are for encased stems which should be used in areas subject to freezing or where the stems are to be buried in rock riprap.

#### b. Unencased stems

Below the diagonal line, support spacings are listed for unencased stems to be used in geographic areas not subject to freezing. Unencased stems cannot be buried. When the distance between supports becomes smaller, an encased stem becomes cheaper. A reminder

of this fact is indicated on this figure and in the previous discussion of Figure D-2. Obviously the comparison should be made only when the unencased stem might be used.

## B. Hydraulic Controls

The cost of stem controlled gates varies directly with gate size and also with head. At some combination of head-gate diameter, the cost of hydraulic controls becomes cheaper than the stem control. A black dashed diagonal line curving downward to the right across the face of the chart delineates approximately a break-even point between the two systems. Comparison between the two control systems was discussed in II, DESCRIPTION OF SYSTEMS.

Anchorage requirements and selection of two components for the hydraulic system is simplified by the "Selection Chart for Hydraulic Cylinders", Figure D-21. The following are components or considerations that require evaluation in a hydraulic system:

### 1. Cylinder Mount

Before the actual cylinder size is determined the type of cylinder mount should be selected. Structure type and gate details are factors in this selection. Several types of mounts for typical applications are shown on Figures D-20 and D-22.

### 2. Thrust

Enter Chart I (Figure D-21) with head on the gate and gate area (including allowance for gate seats). From the intersection of lines projected from these values move downward to the right parallel to the 45° guide lines to Chart 2. When the extended line reaches the point corresponding to the weight of the gate slide, turn horizontally to right and read thrust on cylinder mount. This thrust is the maximum force required to overcome static friction between gate seats and the pull of gravity on the slide.

### 3. Cylinder and Rod

From the thrust value, continue horizontally into Chart 3 to intersection with a vertical line projected from the value of "L" at the bottom of the chart. "L" shown schematically in the diagram in the upper right corner of Figure D-21 is the unsupported length of the rod and depends on the location of the cylinder mount.

Chart 3 is divided into 14 irregular shaped zones defined by the heavy black lines and labeled with a cylinder bore size enclosed in a circle. Beside each bore size is the area of the piston that is effective in the pull or retracting stroke. The abbreviation Std or O.S. following the area indicates whether the piston rod is standard or oversize. Each zone is divided into two areas: the red area represents pressures between 2000 and 3000 psi with the higher values at the top of the area; the white area represents pressures below 2000 psi.

A point on Chart 3 for a combination of thrust and distance (L) determines the cylinder requirements: pressure (greater or less than 2000), bore, and rod type (standard or oversize).

#### 4. Reservoir

Minimum reservoir capacity for oil storage is the volume of the cylinder less that displaced by the piston and rod. Displacement of an oversize rod is greater than that for the standard rod. Chart 4 of Figure D-21 takes this in account by providing two vertical scales for a given cylinder bore size. The horizontal scale of Chart 4 is graduated for values of stroke which is the distance the piston must move to open the gate slide to clear the opening, usually gate diameter plus 3 inches. Having determined the cylinder and stroke requirements, an intersection of lines projected from these values will establish a point on Chart 4 from which reservoir capacity can be interpolated. A standard reservoir of this size or larger is required to keep the pump full.

#### 5. Pumps

Every hydraulic gate control system will have a hand pump, alone, or as an auxiliary to a powered unit. The requirement is simple: to develop the required pressure in the cylinder with a reasonable force on the handle. The rate of flow will be dependent on the operator.

The pump for a powered installation will be selected according to pressure requirement of the system, about as follows:-

<u>Pressure Required</u>	<u>Pump Type</u>
to 1200-1500 psi	gear
to 2000-2500 psi	vane
to 2000-3000 psi	axial-piston

Electric power is more convenient to control and economical if it is reliable and available close to the installation. A gasoline engine can be adapted to any location. Either type should drive the pump at the proper speed. See Design Details.

## 6. Valves

A four-way rotary-type selector valve will provide the required control and sealing characteristics for the majority of SCS installations. Port sizes will depend on the tubing to be used. Other choices are concerned with the type of circulation patterns.

### For Conditions

Handpowered system single cylinder	- use closed-center
Powered system single cylinder	- use open-center to allow for free oil return to tank
Powered system multiple cylinder	- use closed-center valves with pilot-operated relief valve as by-pass

## 7. Tubing

The basic requirements of tubing are (1) to contain maximum working pressure, (2) to pass the required flow with reasonable friction loss, and (3) to resist the environmental conditions in which it must be placed. The following are guides for this selection:

### For Conditions

Enclosed - above water	- use carbon steel tubing or
Exposed to weather	- use carbon steel tubing (plated or coated) or
Conduit enclosed (submerged)	- use pressure hose SAE (100R <sub>1</sub> or 100R <sub>2</sub> )
Direct burial (submerged)	- use stainless steel

Refer to manufacturers' catalogs for pressure ratings of tubing or hose in different sizes.

## 8. Fluid

The hydraulic fluid should be selected on the recommendations of the component manufacturers for the conditions of climate and exposure in the vicinity of the installation.

# V. DESIGN DETAILS

## A. Mechanical System

Several of the necessary accessories to a mechanical system are described in the following figures and illustrated at such a scale that they may be traced full size or assembled with other selected details for photographic reproduction, as described in Section H.

### 1. Gate Stem Encasement Selection Chart, Figure D-2

Figure D-2 is of value only where an unencased stem is being given serious consideration. Omitting the encasement results in economy only when the pedestal spacing exceeds some limiting dimension.

Entering Figure D-2 with the unencased stem spacing obtained from Figure D-1 and moving vertically till it intersects the selected stem diameter will provide a rapid answer. An intersection in the unshaded zone indicates an unencased stem is cheaper; in the shaded zone, the encased stem is cheaper.

Approximate costs per foot of stem for either type installation may be taken from this chart. The line forming the boundary between the shaded and unshaded areas pertains to the encased stem. Its intersection with the stem diameter lines approximates the construction cost. For the unencased stem, intersection of the pedestal spacing with the stem diameter regardless of the zone it is in approximates the construction cost.

### 2. Gate Stem Details, Figures D-3, D-4

Figures D-3 and D-4, Gate Stem Details, pictures the typical installations of encased gate stems and details of splices for both types. D-3 details are used on drawings that are to be reduced for reproduction. D-4 details are of a suitable scale for direct use on drawings to be used full size. The table on D-3 contains dimensions and other values necessary to complete the details in either scale.

### 3. Gate Stem Pedestal, Figure D-5

Figure D-5, Gate Stem Pedestal, illustrates the recommended pedestal for support of any size gate stem at any spacing. Either of three guides may be used as shown in Figures D-6, D-7 or D-8. As noted on the drawings, riprap should not cover an unencased stem.

### 4. Gate Stem Guide and Vent Pipe Hanger, Figures D-6, D-7, D-8

Figures D-6, D-7 and D-8, Gate Stem Guide and Vent Pipe Hanger, show three devices for mounting gate stem to pedestals.

D-6 uses standard U-bolts and channel section and requires no welding.

D-7 uses steel bars bent and drilled to support the stem, encasement and vent pipe.

D-8 illustrates a stem guide typical of those supplied by gate manufacturers, usually of cast iron, and available with bronze bushings as an option. This type is designed to fit closely to a gate stem and ordinarily is not intended for use with encasement.

### 5. Gate Lift Pedestal, Figure D-9

Figure D-9, Gate Lift Pedestals, provides outline dimensions and quantities for the sizes A through E referred from Figure D-1.

Drawings 7-L-20544 (A-E) listed in the table show construction details including reinforcing steel for each size and are included on Figures D-10 thru D-14. On sized D and E the cranks are oriented to require the least stooping or bending of the operator.

### 6. Handwheel Bracket and Base Plate, Figures D-15, D-16, D-17

Figure D-15 thru D-17, Handwheel Bracket Base Plate, give detailed dimensions for fabrication of brackets and base plates for mounting lifts on pedestals.

## B. Hydraulic System

Some details of installation that differ from a mechanical system are shown in Figure D-22, Typical Details. It is most important to note the relationships of dimensions  $E_g$  and  $E_y$

to make a secure fastening to the gate slide and to provide adequate clearance for slide and frame in all parts of the operating cycle. Modification of the stem block is needed to permit threading the block to the piston rod without turning the piston in the cylinder or turning the cylinder itself. The wrench flats are located (dimension Eg) so as to be accessible for holding the rod during the entire threading operation.

The simplest installation uses a flange mount cylinder attached to a yoke on the gate frame. This assembly can be fabricated, assembled and tested under shop conditions before field installation. A side foot mount is applicable in many cases but anchor bolts must be located carefully to avoid difficult field adjustments. A steel plate, slotted for the anchor bolts, serve as an intermediate adjustable mounting on which to bolt this type cylinder. A third method, using the trunnion mount, has built-in flexibility in one plane of movement and can be used to advantage in special situations, (limited head room) as illustrated.

Safety devices for the system itself are suggested in the following order:

1. A pressure gage, marked with the design opening and closing pressures, will be sufficient for a handpowered system and competent operator.
2. Pressure relief valves, set for design opening or closing pressures and placed in the respective side of the circuit, guard against excess pressures applied by unknowing or unauthorized hand operators or an unattended power unit.
3. A travel limit circuit allows oil to bypass the cylinder when the gate is completely open or closed and eliminates the continuous blowoff of the relief valves if a powered unit is not continuously watched during operation.

For a power installation, additional calculations are required. The power requirement is set by the amount of work and the time allowed.

From the previous example of a 30" x 30" gate, the work for one inch of gate movement was 14,600 inch pounds. Assuming a maximum allowable time for opening of 5 minutes, the power is found in this manner:

$$\begin{aligned}
 \text{HP} &= \frac{\text{Work}}{\text{Time}} \\
 \text{HP} &= \frac{(14,600 \text{ in-lb}) (32 \text{ in.})}{\left(12 \frac{\text{in}}{\text{ft}}\right) (\text{in}) (5 \text{ min}) \frac{(33,000 \text{ ft-lb})}{\text{min HP}}} \\
 &= 0.236 \text{ HP}
 \end{aligned}$$

The oil flow requirement of the system for opening the gate is:

$$\begin{aligned}
 \text{Vol} &= \frac{(6.811 \text{ in}^2) (32 \text{ in.})}{(5 \text{ min})} \\
 &= 43.6 \text{ cu in. per minute}
 \end{aligned}$$

A typical pump for such an installation will deliver about 1.2 cubic inches of oil per revolution. The required speed of the pump is then:

$$\begin{aligned}
 \text{Rev} &= \frac{(43.6 \text{ in}^3)}{\left(1.2 \frac{\text{in}^3}{\text{rev}}\right)} \\
 &= 36.4 \text{ revolutions per minute}
 \end{aligned}$$

An electric motor of 1/4 or 1/3 HP rating should be adequate for this intermittent use. The common motor speed of 1,760 rpm must be reduced to the 36 rpm of the pump by gear, chain or belt drive. Without speed reduction the pump would attempt its full output against the operating pressure of the cylinder resulting in an overload on the power unit.

The remote location of most reservoirs suggests the use of a gasoline engine. The usual procedure for selecting a gasoline engine is to require 50% more power than the load. For the example, however, there are few choices available less than about 2 HP. As with the electric motor, the speed must be reduced to the speed of the pump.

When a hand pump is used as an auxiliary to a powered pump, it must be installed parallel to the powered pump and the discharge line of each guarded by a check valve against back-flow induced by the other unit.

Ideally the control station circuitry and the cylinder assembly at the gate should be shop assembled by workmen with hydraulics equipment experience. Both assemblies can then be tested and adjusted under shop conditions. Quick couplers might be used for the final connections reducing much of the

mess and the hazard of contamination usually attendant with field assembly. This approach to the installation process should result in compact, neat assemblies, fully tested and ready for service.

Sample specifications for the usual items of hydraulic equipment are included in Section VII as a guide for bid preparation.

## VI. EXAMPLE

Continuing the example of the previous sections, the following procedure illustrates the selection of additional details required on the construction drawings. This example assumes the drawings will be reduced from "E" size (21 x 30) to "L" size (10 1/2" x 15").

This example in detail selection is restricted to the mechanical system of controls since no standard details have been developed for the hydraulic alternate.

Given: The earth dam example of Section B, with choices of 20" steel pipe, 21" R/C pipe or 24" CMP, and a head of 20 ft.

Determine: The size of the gate control components for each of the three pipe sizes and details for the construction drawings.

### Problem Analysis:

1. Find stem diameter required.
2. Find stem pedestal spacing required.
3. Find lift pedestal size required.
4. Find lift type required.
5. Find vent pipe size required.
6. Determine construction drawing details.
7. Find requirements of an alternate hydraulic control system for comparison with the mechanical system.

### Solution:

1. Since a stock gate is available for each of the conduit sizes, three solutions are possible. Enter Figure D-1 with the conduit diameter plus three inches and a 20'-0" depth of water to gate centerline.
2. The inlet structure size was selected in Section C. The rest of the components tabulated below can be obtained from Figure D-1.

Conduit Dia Item	20" Steel	21" R/C	24" CMP
Conduit dia + 3"	23"	24"	27"
Inlet structure size	G	H	H
Stem diameter	1 1/2"	1 1/2"	1 1/2"
Stem pedestal spacing			
Encased	16'-0"	16'-0"	16'-0"
Unencased	10'-6"	10'-6"	10'-0"
Lift pedestal size	C	C	C
Lift type	30" handwheel	24" handwheel (ball bearing)	30" handwheel (ball bearing)
Alternate hydraulic control	consider	consider	consider

3. In the mechanical system the only alternate choice is between the encased and unencased stem. The encased stem is selected because of icing conditions and burial of the stem in rock riprap placed on the embankment for erosion protection. For the remainder of the control details, select the following common to all three pipe sizes:

Gate stem details	Figure D-3
Gate stem pedestal	" D-5
Gate stem guide	" D-6
Lift pedestal	
Concrete quantity and Std Dwg No.	" D-9
Base plate detail	" D-16

Circled blanks on Figure D-3 indicate information that is to be filled in. The stem diameter was previously found to be 1 1/2". The following related information is found on Figure D-3.

- a. Stem splice 1 1/2" x 9" heavy wall seamless steel tubing
- b. Rivets 2 - 5/8 x 3"
- c. Encasement 2 1/2" standard galvanized pipe
- d. Oil 0.627 qts of SAE 20 motor oil per foot of encasement

On Figure D-6, in addition to the information related to the stem diameter listed on the same figure, a 2" vent pipe was found required for this job from Figure C-6.

4. The procedure for selecting the alternate hydraulic controls is presented using the 24" CMP pipe from the previous example.

Assume a 24" rectangular gate weighing approximately 200#, average for this type of gate.

- a. Enter Figure D-21 with the area enclosed by the gate seats  $(24 + 3)(24 + 3) = 5.06 \text{ ft}^2$  and  $H = 20 \text{ ft}$  and find the intersection point. From this point move diagonally down to the right along the  $45^\circ$  grid to about 200# gate weight. Move horizontally from this point to find 4700# thrust.
- b. The required stroke is  $24 + 4 = 28"$ . Using a front end cylinder mount the unsupported rod length,  $L$ , is 28" plus extra length required by the gate slide frame. This extra distance according to the catalogues reviewed is about  $1/4$  the gate size. Therefore, using 6" plus 2" for clearance at the cylinder support the total unsupported rod length is then  $28 + 6 + 2 = 36"$ .
- c. Enter Figure D-21, Chart 3 with thrust = 4700 lbs and  $L = 36"$  and find a 2" bore with an oversize rod. Also find operating pressure in the 2000 to 3000 psi zone.
- d. Enter Figure D-21, Chart 4 using the 28" stroke and a 2" cylinder bore size with an oversized rod and find the required reservoir capacity of 50 cubic inches.
- e. Using Figure D-23 and requiring a front trunnion mount, the following cylinder makes and models can be used:
  1. Carter model no. ENS
  2. Hannifin model no. D-H10
  3. Miller model no. H81
- f. The example installation can be easily operated by a hand pump. For the 3000 psi requirement, select a pump with about a  $3/4$  in. piston. Displacement for each comfortable stroke will be about 0.25 cu in. and about 6.5 strokes will move the gate up one inch. Several pumps meeting these requirements are obtainable with integral reservoirs that are equal to or greater than the minimum capacity requirement of 45 cu in.
- g. Assuming that the hydraulic lines are to be buried separately from the air vent, stainless steel is the required material.  $1/4$  inch diameter would carry the required flow of oil but  $3/8$  inch will probably justify its extra cost in effort saved. Wall thickness should be 0.028 inches.
- h. Select a four-way rotary selector valve ported for  $3/8$  tubing. For this hand-powered installation a closed center will give the desired circulation pattern.



## VII. SAMPLE MATERIAL SPECIFICATION

A. Hydraulic ControlsSAMPLE MATERIAL SPECIFICATION310. HYDRAULIC CONTROLS1. SCOPE

This specification covers the quality of hydraulic controls for slide gates.

2. GENERAL REQUIREMENTS

The hydraulic controls, including cylinder, pump, valves, lines and fittings, shall conform to the requirements of the Joint Industry Conference (JIC) Hydraulic Standards for Industrial Equipment, Revised April 1959.

3. CYLINDER

The cylinder shall be selected from the JIC Interchangeable Series rated for 2000 psi operating or 3000 psi non-shock loading.

The piston rod shall be stainless steel with threads and wrench flats machined as required to meet mounting requirements as shown on the drawings.

Seals for the piston and the rod bearing shall be the multiple-V type or shall have equivalent sealing characteristics. A metallic external wiping ring shall be incorporated with the rod bearing.

4. PUMP

A hand operated pump shall be capable of developing the design pressure with not more than 60 pounds force on the handle. It shall be equipped with a check valve to prevent backflow between power strokes.

A pump for use with engine or electric motor drive shall deliver oil at the specified rate and pressure without overload on the power unit. The pump and power unit shall be aligned so that bearing loads, stresses in connecting elements and losses due to friction are no greater than for normal power transmission.

5. RESERVOIR

A reservoir shall be supplied with capacity as specified or shown in the drawings. Provision shall be made for filtering the

hydraulic fluid during filling. Piping for the return flow shall enter the reservoir below the normal operating level of the field. A breather hole shall be provided and shall be protected by an air cleaner.

6. VALVES

All valves shall have a working pressure rating at least equal to the maximum operating pressures of the system.

The control valve shall be a 4-way rotary selector valve of the disc type, equipped for oil service. The seals shall limit internal leakage to 1 drop per minute at the rated pressure. External leakage shall be zero. The center shall be open or closed as specified or shown on the drawings.

Relief valves shall be adjustable within the range of 50% to 100% of maximum rated pressure. The adjustment shall be secured by a locknut or protective cover.

Bypass valves, when included in a travel limit circuit, shall have capacity equal to the pumping rate of the system for normal operation.

7. HYDRAULIC LINES

All hydraulic lines shall have working pressure ratings at least equal to the maximum operating pressure of the system with a safety factor (based on bursting strength) of 4.

Hydraulic lines that will be located under water or inaccessible for regular inspection shall be stainless steel tubing or pressure hose of synthetic rubber or plastic with wire or synthetic fiber reinforcing. Fittings for either tubing or hose shall be stainless steel. Hose fittings shall be permanently attached by factory methods. Fittings shall allow no leakage and shall not unduly restrict flow in the passages they connect.

For that part of the piping protected from the weather and accessible for regular inspection seamless carbon steel tubing can be used. Fittings shall have corrosion protection of cadmium plating or equal. If dissimilar metals must be joined, protection against galvanic corrosion shall be provided.

Metallic hose couplings that will be dragged into place in a conduit shall have a wrapping of coal-tar tape of thickness sufficient to provide a water proof cover after installation.

8. HYDRAULIC FLUID

Hydraulic fluid shall be supplied in accordance with the manufacturer's recommendations for the equipment supplied and the operating conditions stated under Construction Details.

9. INSTALLATION INSTRUCTIONS

The manufacturer shall submit complete installation data including instructions for adjustment for all components supplied for this system.

10. PAINTING

Each item of equipment shall have paint protection for all metal except stainless steel or electroplated metallic surfaces.

The cylinder and other components that will be submerged shall have protection against such exposure. In the absence of a paint option certified by the manufacturer for such conditions, these items will be painted by System I under Specification 22, Cleaning and Painting Metalwork.

Other components, housed in the control station, shall have paint coatings equal to Paint System D or E under Specification 22.



B. Installing Hydraulically Operated Slide GatesSAMPLE CONSTRUCTION SPECIFICATION210. INSTALLING HYDRAULICALLY OPERATED SLIDE GATES1. SCOPE

The work shall consist of furnishing and installing hydraulically operated slide gates, complete with all controls and other necessary appurtenances.

2. MATERIALS

The gates and controls furnished shall conform to the requirements of Material Specifications 128, 134 and 300. All gates shall be furnished complete with hydraulic hoisting equipment and other necessary appurtenances.

3. INSTALLING GATES

The Contractor shall install the gates in a manner that will prevent leakage around the seats or binding of the gates during operation.

Surfaces of metal against which concrete will be placed shall be unpainted and free from oil, grease, loose mill scale, surface rust and other debris or objectionable coatings.

Anchor bolts, thimbles and spigot frames shall be secured in true position in the forms and held in alignment during the placement of concrete.

Concrete surfaces against which rubber seals will bear or against which flat frames or plates are to be installed shall be finished to provide a smooth and uniform contact surface. When flat frames are installed against concrete, a layer of bedding mortar shall be placed between the frame and the concrete.

4. INSTALLING HYDRAULIC ASSEMBLY

The hydraulic cylinder, pump, valves, connecting lines and fittings shall be installed in accordance with the manufacturer's recommendations and as shown on the drawings, unless otherwise approved by the Engineer.

The cylinder shall be mounted as shown on the drawings. Alignment shall be established so that neither gate nor cylinder will bind during any phase of operation.

5. OPERATIONAL TESTS

After the gate and hydraulic lift assembly have been installed, they shall be cleaned, lubricated and otherwise serviced by the Constructor in accordance with the manufacturer's instructions.

The gate will be required to maintain a set position for twenty-four (24) hours with a maximum permissible movement due to internal leakage of 0.25 inches. The Contractor shall test the gate and hydraulic lift assembly by operating the system several times throughout its full range of operation. He shall make any changes and adjustments that are necessary to insure satisfactory operation of the gate system subject to approval of the Contracting Officer.

6. MEASUREMENT AND PAYMENT

The work will not be measured. Payment for the hydraulically operated slide gate assembly will be made at the contract lump sum price. Such payment will constitute full compensation for all labor, materials, equipment and all other items necessary and incidental to the completion of the work including furnishing and installing anchor bolts, housing and all specified appurtenances and fittings.

7. TYPICAL CONSTRUCTION DETAILS AND ITEMS OF WORK

Class of gate - 00-00 (seating - unseating head)  
Type of frame (flat, spigot, flange, etc.)  
Type and size of opening (square, round, etc.)  
Type of wedge (cast iron, bronze, etc.)  
Type of seating surfaces (cast iron, bronze, etc.)  
Special gate requirement (self contained, nonrising stem, flush bottom opening, etc.)  
Type, capacity of hydraulic control system

The stem block shall be shaped so as to turn in the gate recess for threading to the piston rod.

The maximum operating pressure for this system (opening) will be \_\_\_\_\_ psi.

The operating pressure for closing will be \_\_\_\_\_ psi.

The range of temperature for operation of this system will be from - \_\_\_\_\_ °F to + \_\_\_\_\_ °F.

The cylinder shall have \_\_\_\_\_" bore, \_\_\_\_\_" stroke \_\_\_\_\_ mounting style. Piston rod extensions, wrench flat and port locations shall be included as detailed on the drawings.

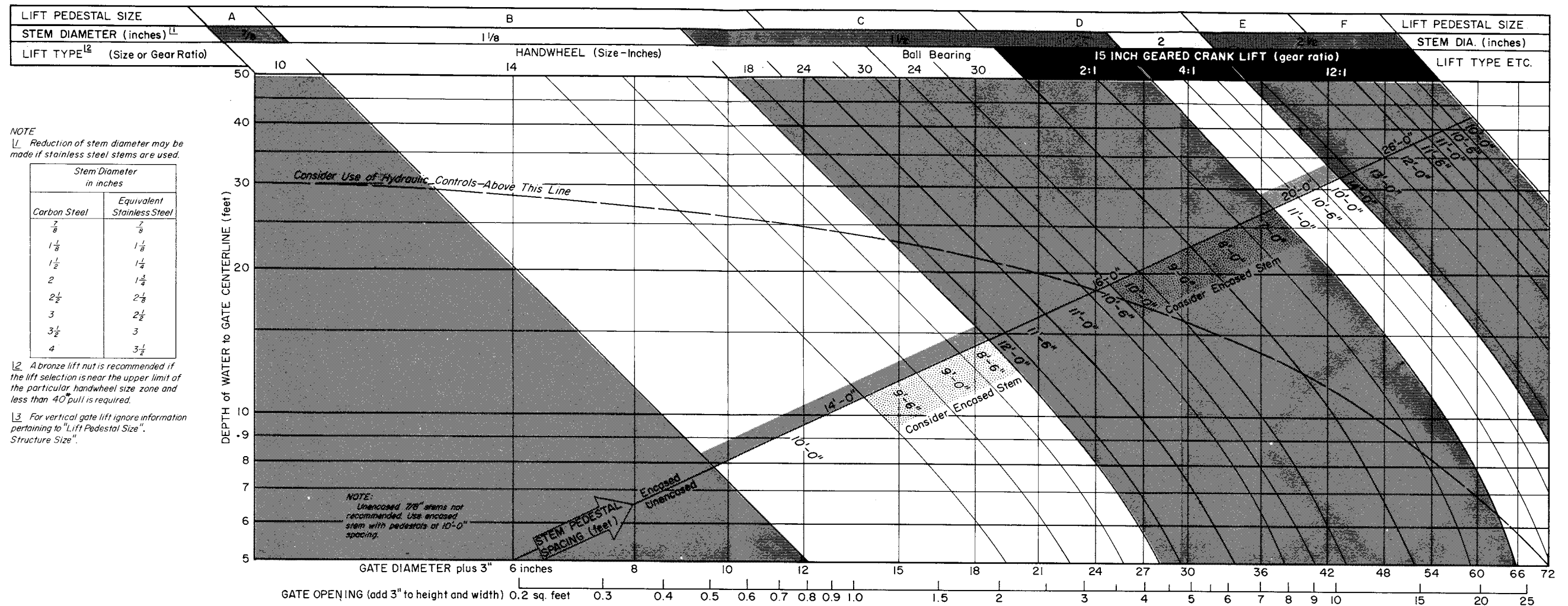
The pump shall have a pressure capability of \_\_\_\_\_ psi. Volume of flow shall be in the range \_\_\_\_\_ (gpm, cu in/min) to \_\_\_\_\_ (gpm, cu in/min).

The reservoir shall have a minimum capacity of \_\_\_\_\_ cubic inches.

The control valve shall have a (n) (closed or open) center and ports shall be size \_\_\_\_\_ with straight threads.

The relief valves shall be adjustable within the range of \_\_\_\_\_ psi to \_\_\_\_\_ psi. The initial setting(s) shall be \_\_\_\_\_ psi (\_\_\_\_, \_\_\_\_, \_\_\_\_, respectively) as detailed on the drawings.





SELECTION CHART

## EXAMPLE PROBLEM

- GIVEN**
- Outlet Conduit Diameter  $21"$
  - Maximum Water Depth to Centerline of Gate  $20'$

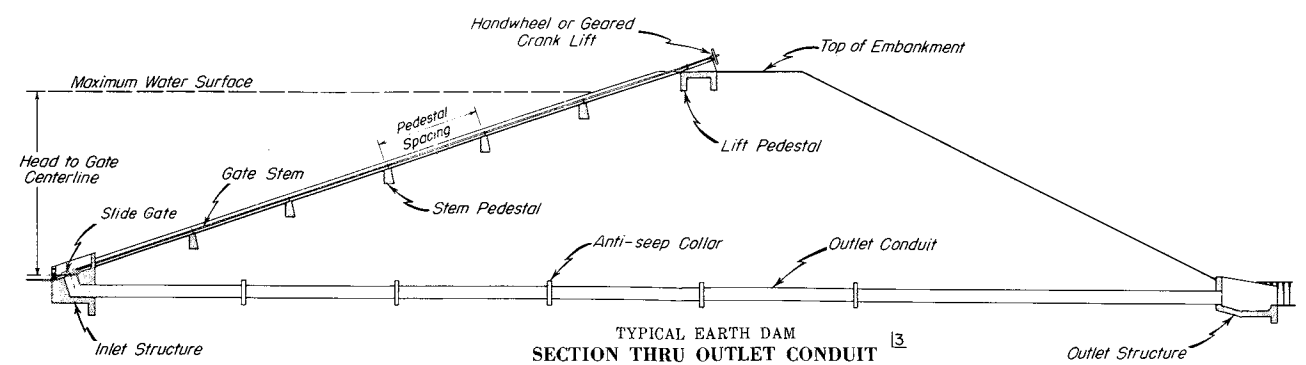
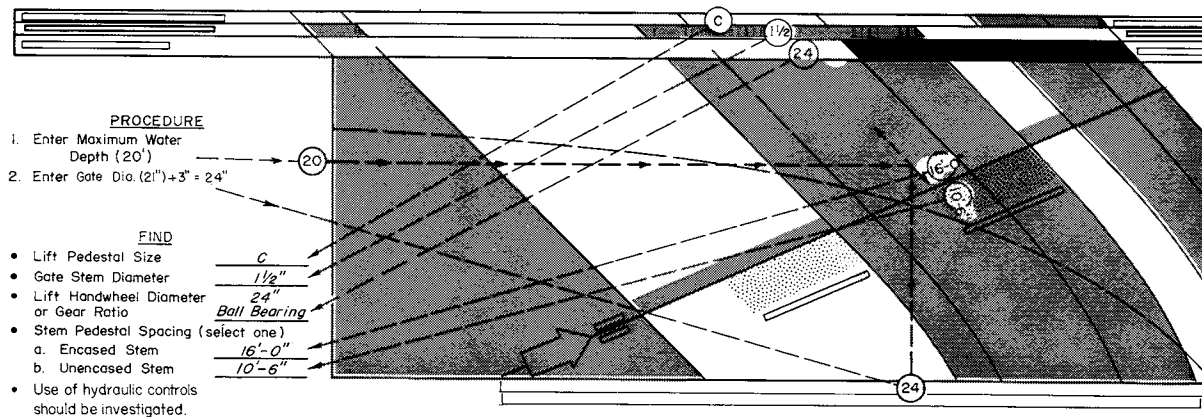
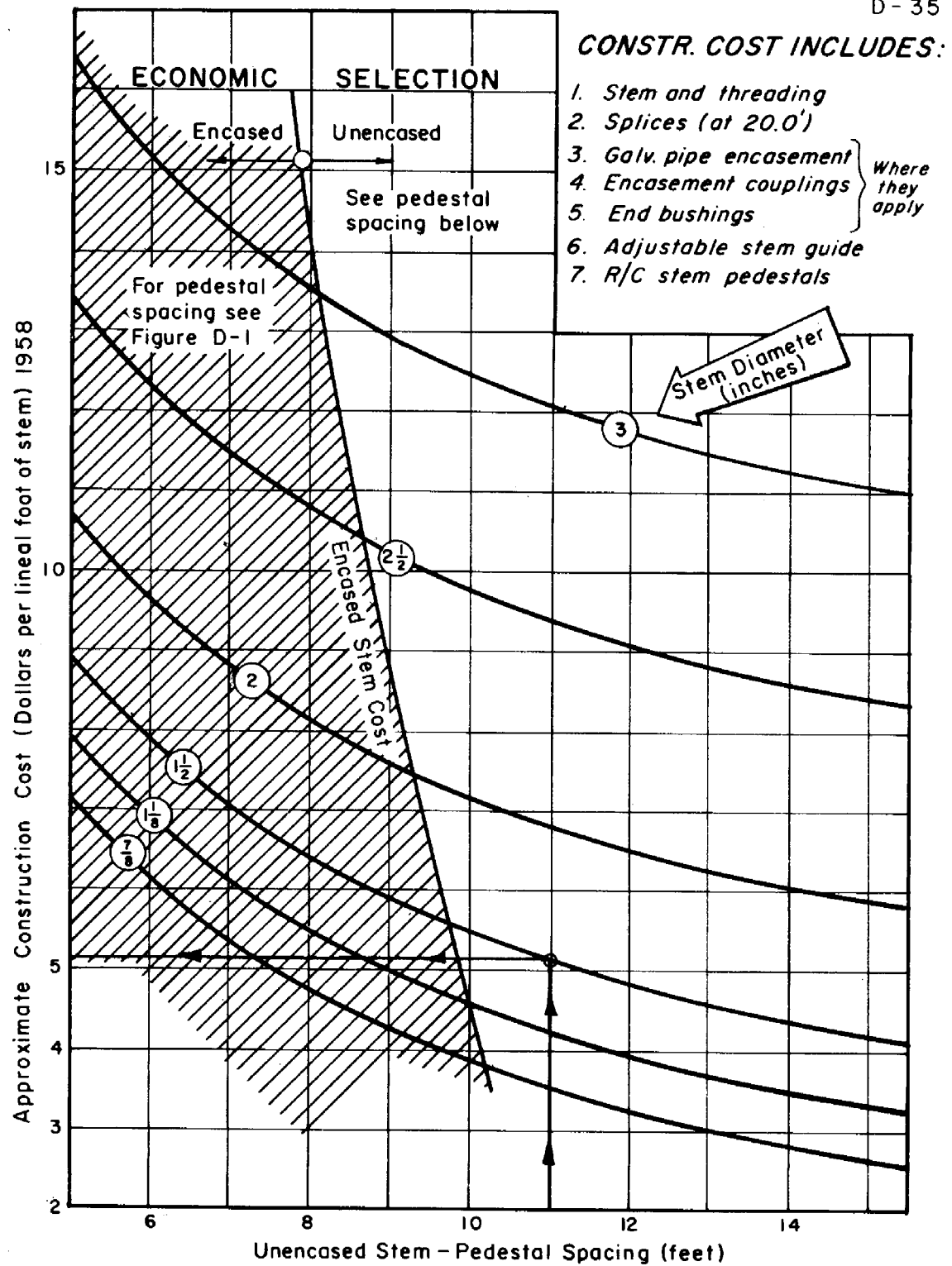


FIGURE D-1  
GATE CONTROL SELECTION CHART  
EWPU Portland, Oregon

**Note:**


Enter this chart with the unencased stem pedestal spacing and stem diameter required to satisfy the head-gate size relation shown in Figure D-1.

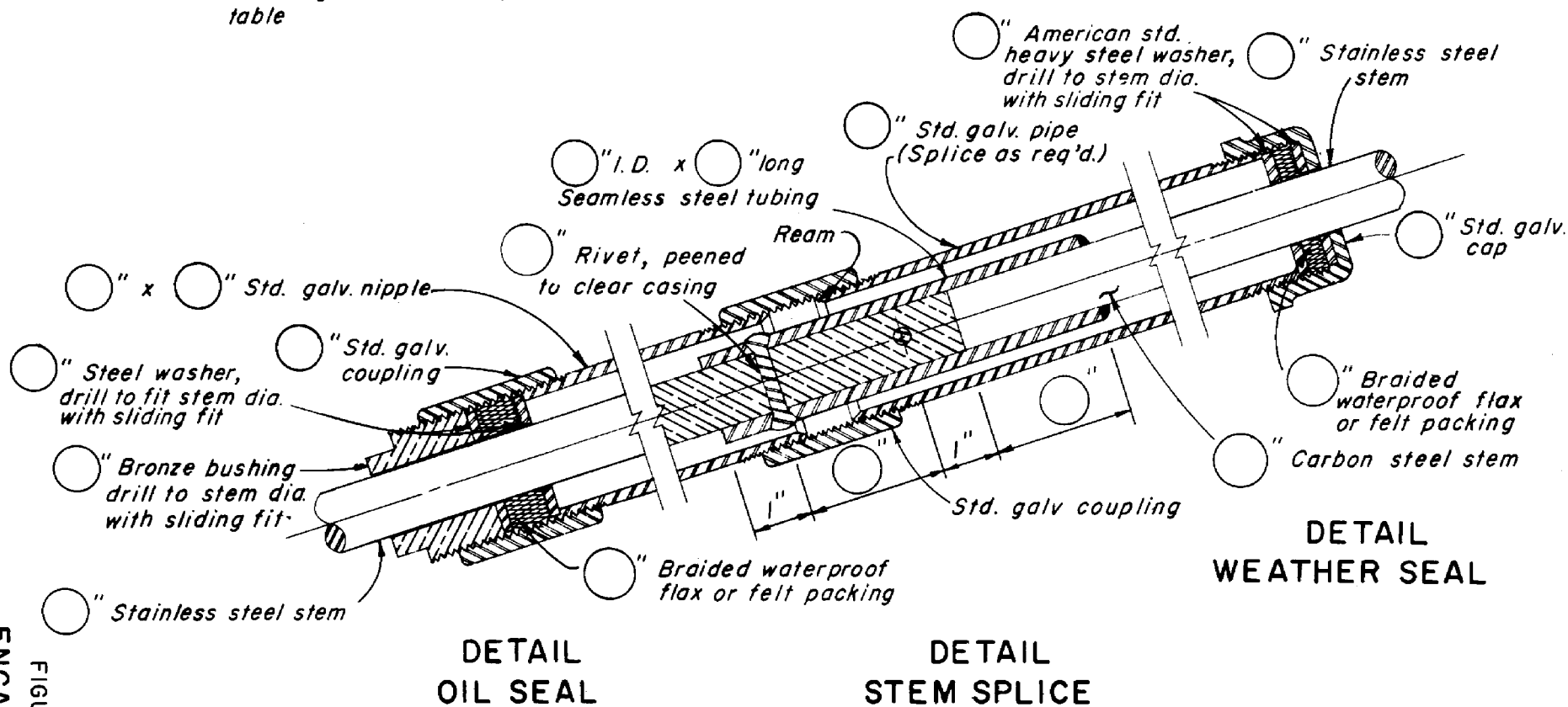
FIGURE D-2  
**GATE STEM ENCASEMENT  
SELECTION CHART**

EWP Unit Portland, Oregon



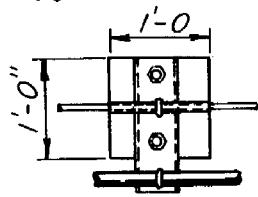
*Place oil seal between gate frame and headwall. See Figure D-3 for splice table*

Fill with SAE 20 motor oil,  
approximately  gallons  
Place weather seal above  
riprapped section clear of  
control structure.

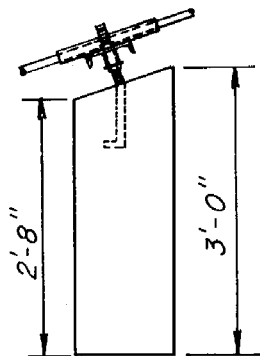


## GATE STEM SPLICE

**FIGURE D-4**  
**ENCASED GATE**  
**STEM DETAILS**  
EWP Unit Portland, Oregon

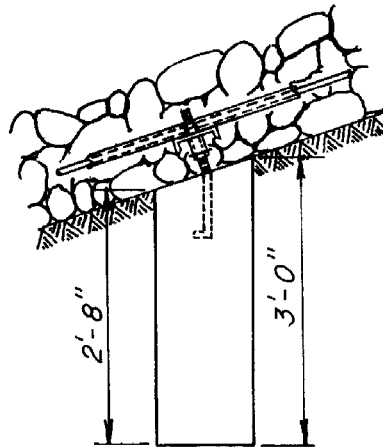


PLAN



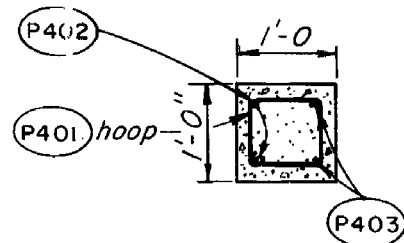
SIDE ELEVATION

UNENCASED

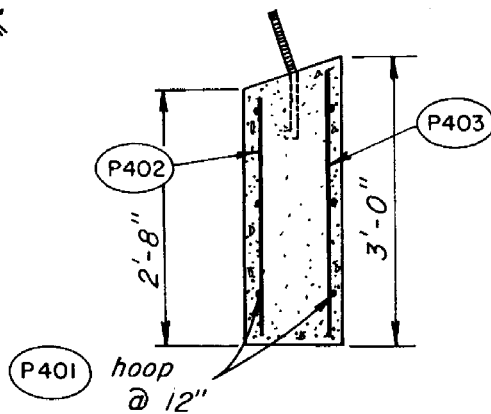


SIDE ELEVATION

ENCASED



PLAN



SECTIONAL ELEVATION

## GATE STEM PEDESTAL



Note:

Location and spacing of anchor bolts vary with type of stem guide used. See Fig. D-6, D-7, D-8.

Concrete volume = 0.105 cu. yds.

Reinforcing steel = 13.682 lbs

## STEEL SCHEDULE

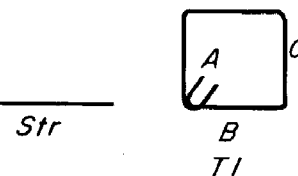
Location	Mark	Size	Quan.	Length	Type	A	B	C	Total Length
<b>GATE STEM PEDESTAL</b>									
	P401	4	3	3'-0"	TI	0'-2"	0'-8"	0'-8"	9'-0"
	P402	4	2	2'-3"	Str				4'-6"
	P403	4	2	2'-9"	Str				5'-6"

Use when construction drawings are to be reduced one half size

## STEEL SCHEDULE

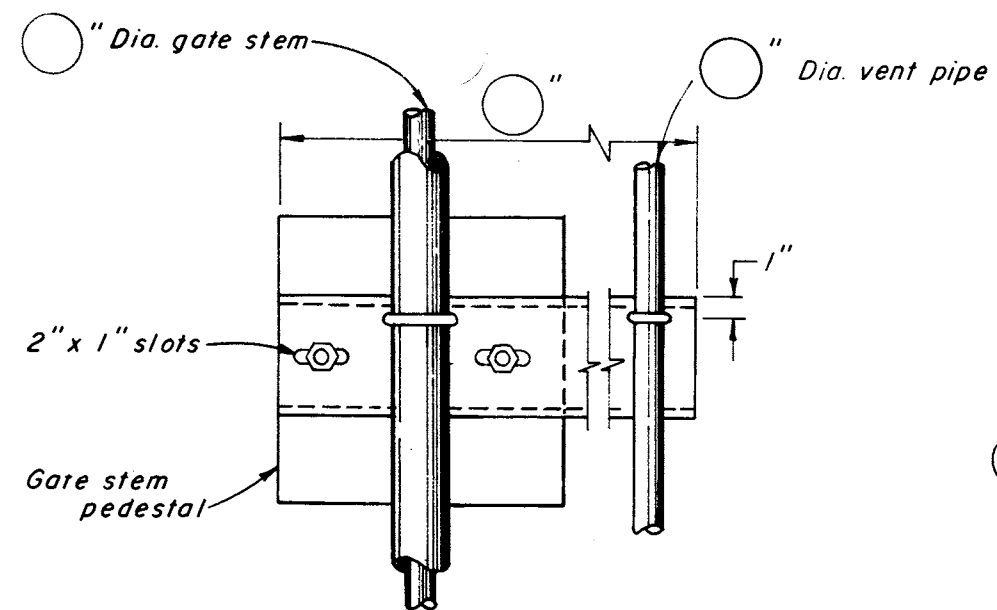
Location	Mark	Size	Quan.	Length	Type	A	B	C	Total Length
<b>GATE STEM PEDESTAL</b>									
	P401	4	3	3'-0"	TI	0'-2"	0'-8"	0'-8"	9'-0"
	P402	4	2	2'-3"	Str				4'-6"
	P403	4	2	2'-9"	Str				5'-6"

Use when construction drawings are to be reproduced full size

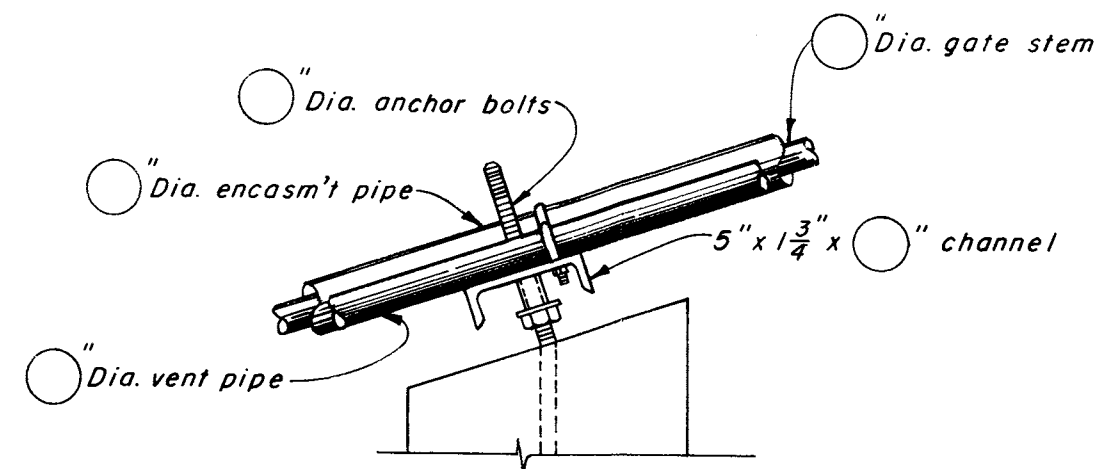


## BAR TYPES

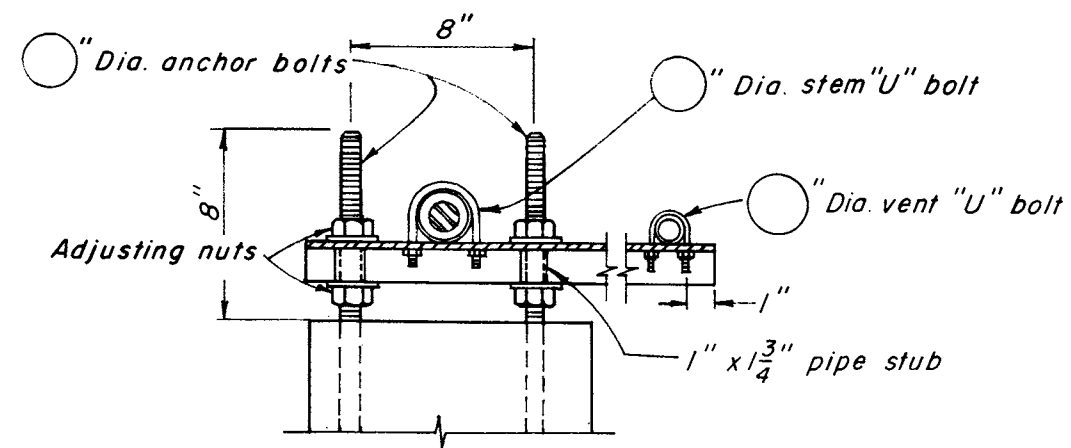
FIGURE D-5  
GATE STEM PEDESTAL  
EWP Unit Portland, Oregon



PLAN



SIDE VIEW



ELEVATION

**Note:**

For unencased stem use 12" pipe stub, the same diameter as encasing pipe, through "U" bolt clamp.

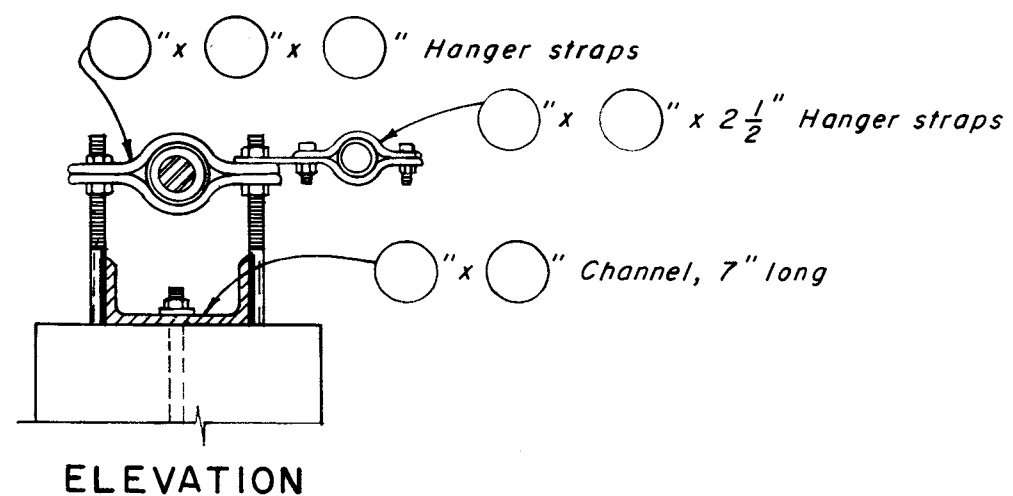
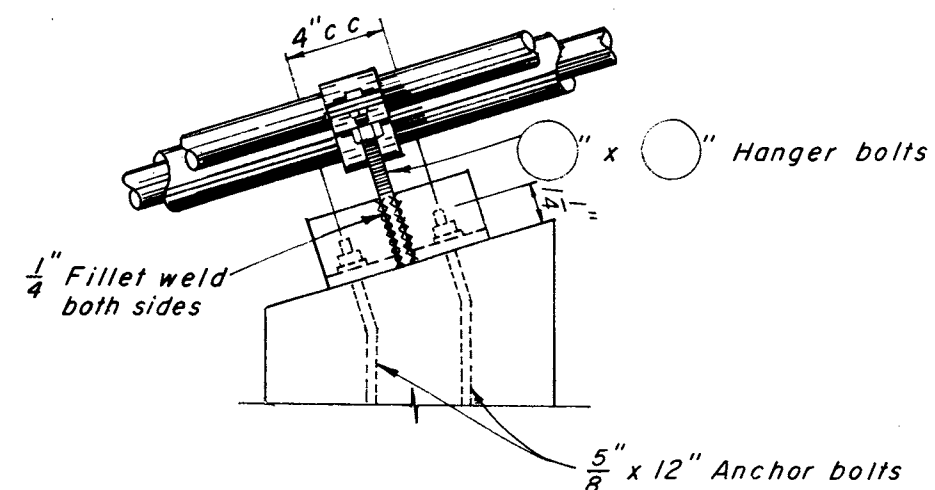
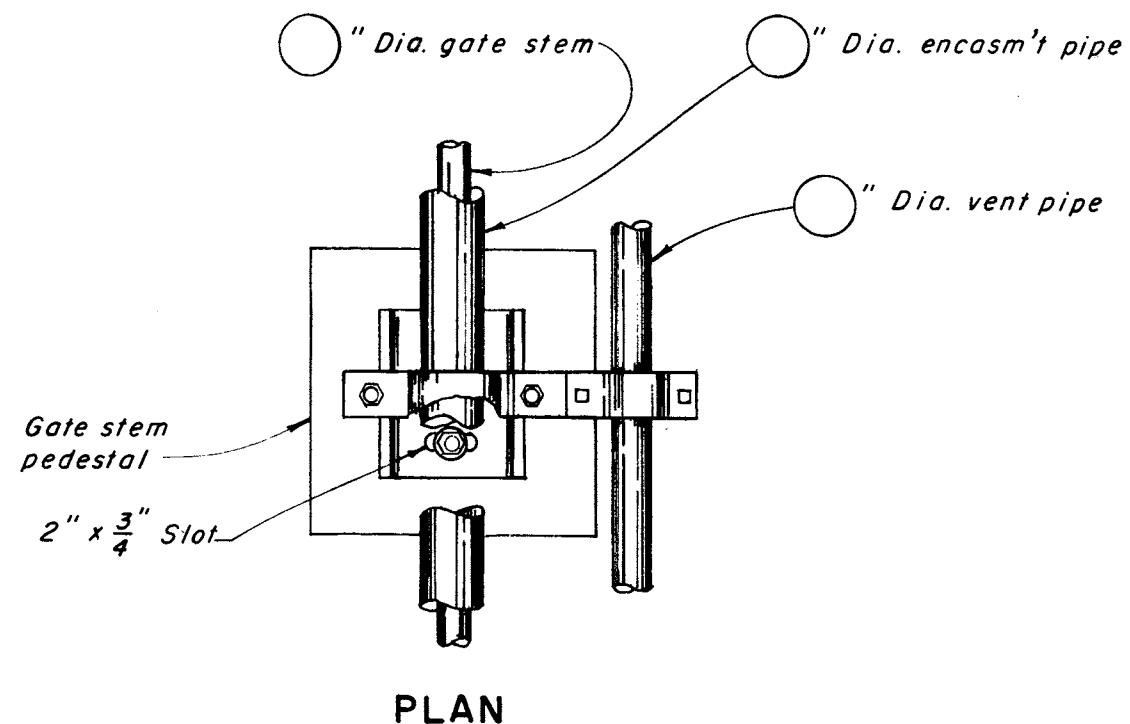
STEM DIA.	ENCASM'T PIPE* DIA.	CHANNEL SIZE 9#/FT.	ANCHOR BOLT	"U" BOLT SIZE (STEM)	"U" BOLT SIZE (VENT)
7/8"	1 1/2"	5" x 1 3/4" x 15"	3/4" x 18"	1 1/2" x 3/8"	Variable
1 1/8"	2"	5" x 1 3/4" x 16"	3/4" x 18"	2" x 3/8"	See Figure C-6 for vent diameter
1 1/2"	2 1/2"	5" x 1 3/4" x 18"	3/4" x 18"	2 1/2" x 1/2"	
2"	3"	5" x 1 3/4" x 19"	3/4" x 18"	3" x 1/2"	
2 1/2"	4"	5" x 1 3/4" x 20"	7/8" x 18"	4" x 1/2"	

\*Std. galv. pipe

**GATE STEM GUIDE**

Not to Scale

FIGURE D-6  
ADJUSTABLE STEM GUIDE  
AND VENT PIPE HANGER  
EWP Unit Portland, Oregon



STEM DIA.	ENCASM'T PIPE* DIA.	CHANNEL SIZE (7" long)	HANGER⊗ STRAP SIZE	HANGER BOLTS
7/8"	1 1/4"	6" x 3" - 16.3 <sup>#</sup>	1 1/4" x 1/4" x 2"	3/4" x 8"
1 1/8"	2"	6" x 3" - 16.3 <sup>#</sup>	2" x 1/4" x 2"	3/4" x 8"
1 1/2"	2 1/2"	7" x 3" - 17.6 <sup>#</sup>	2 1/4" x 3/8" x 2"	7/8" x 8"
2"	3"	7" x 3" - 17.6 <sup>#</sup>	3" x 3/8" x 2 1/2"	7/8" x 8"
2 1/2"	4"	8" x 3 1/2" - 22.8 <sup>#</sup>	4" x 1/2" x 2 1/2"	1" x 9"
3"	5"	9" x 3 1/2" - 25.4 <sup>#</sup>	5" x 1/2" x 2 1/2"	1" x 9"

\* Std. galv. pipe

⊗ Hanger bolt size and spacing requires larger straps than stock fittings provide

## GATE STEM GUIDE

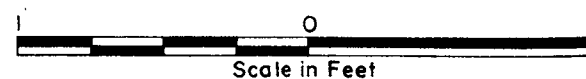
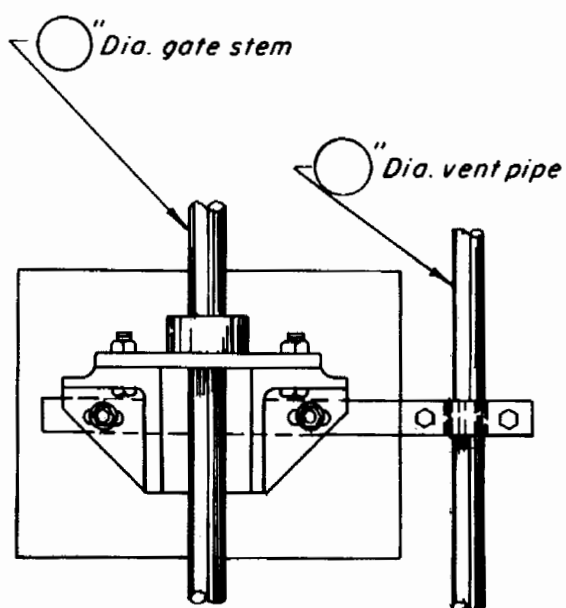
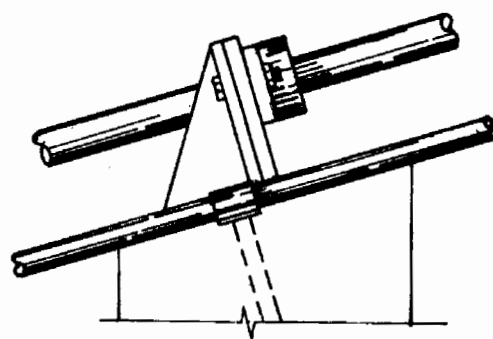


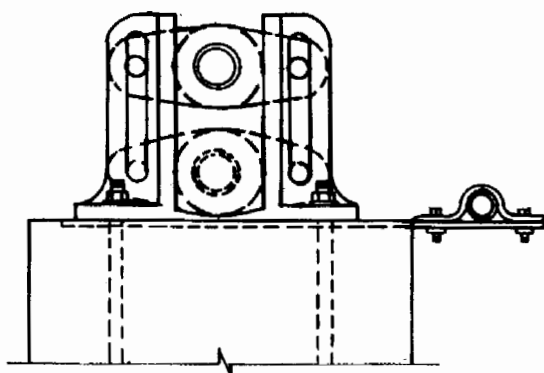
FIGURE D-7  
ADJUSTABLE STEM GUIDE  
AND VENT PIPE HANGER  
EWP Unit Portland, Oregon



PLAN



SIDE VIEW



ELEVATION

Note:

Refer to gate supplier's  
catalog for size selection

## GATE STEM GUIDE

Not to Scale

FIGURE D-8

**ADJUSTABLE STEM GUIDE  
AND VENT PIPE HANGER**

EWP Unit Portland, Oregon

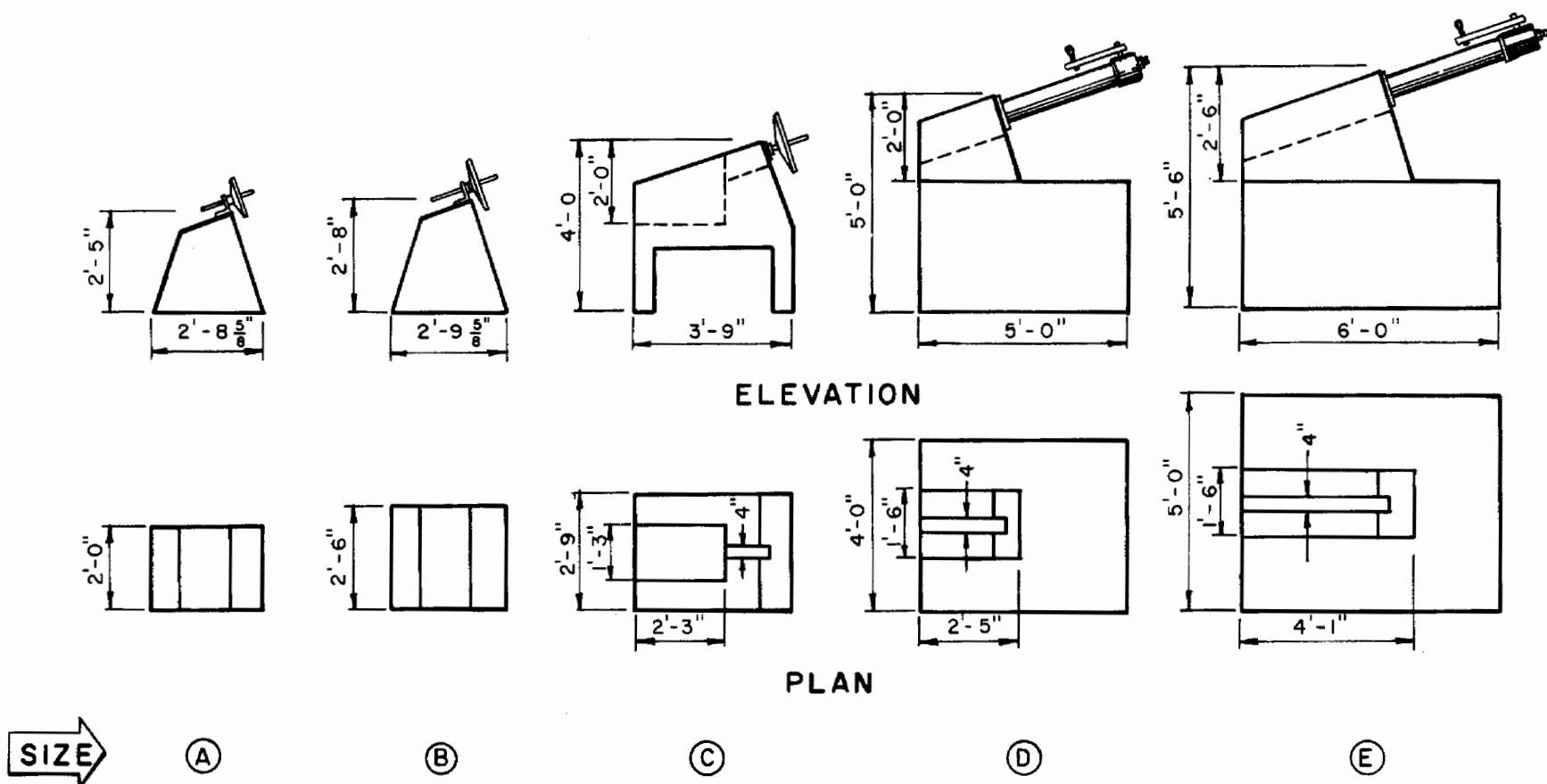
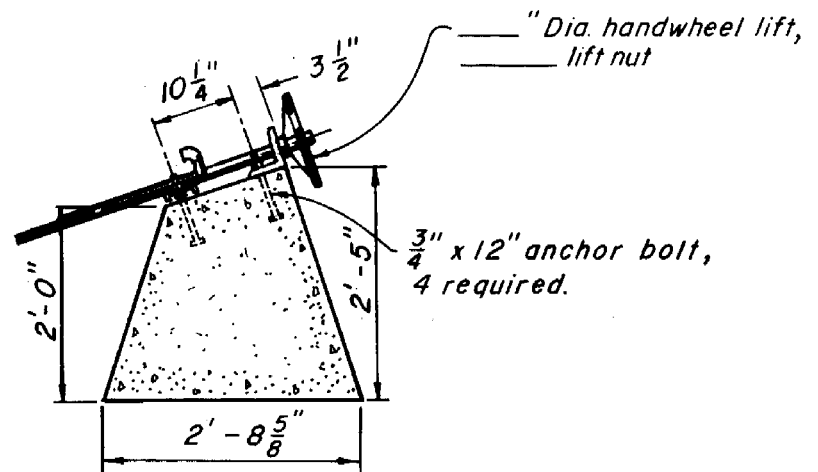
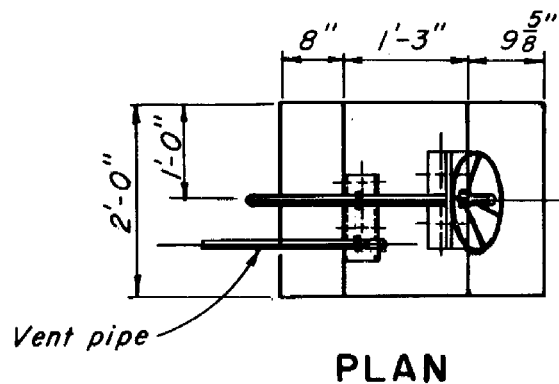


FIGURE D-9  
GATE LIFT PEDESTALS  
EWP Unit Portland, Oregon

SIZE	LIFT CAPACITY	VOLUME CONCRETE	REINF. STEEL	REFER TO DRG. NO. 7-L-20544 A THRU E	BASE PLATE DETAIL FIG.
(A)	200#	0.27 cu. yds.		Fig. No. D-10	D-17
(B)	800#	0.47 cu. yds.		Fig. No. D-11	D-17
(C)	2,200#	0.74 cu. yds.	44.25#	Fig. No. D-12	D-18
(D)	6,000#	2.41 cu. yds.	18.05#	Fig. No. D-13	D-19
(E)	10,000#	3.70 cu. yds.	24.05#	Fig. No. D-14	D-19



SECTIONAL ELEVATION



PLAN

## GATE LIFT PEDESTAL

Note:

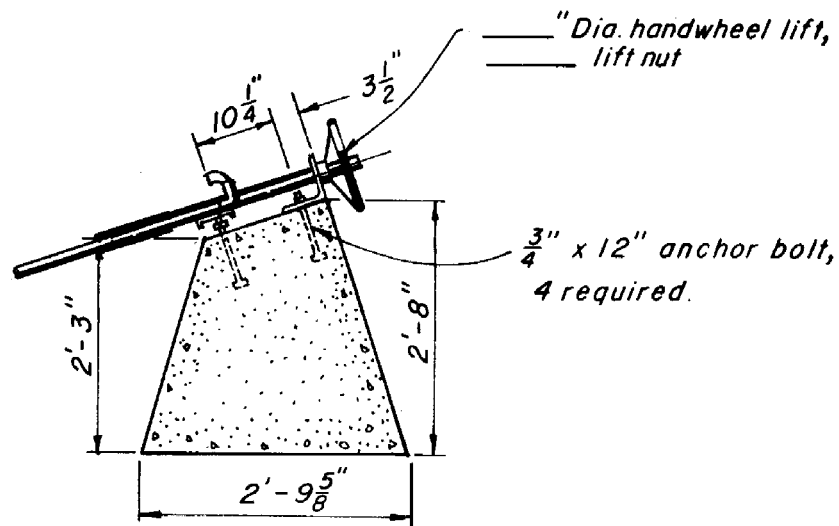
For lift selection and handwheel size refer to Figure D-1.

For handwheel bracket detail see Figure D-17

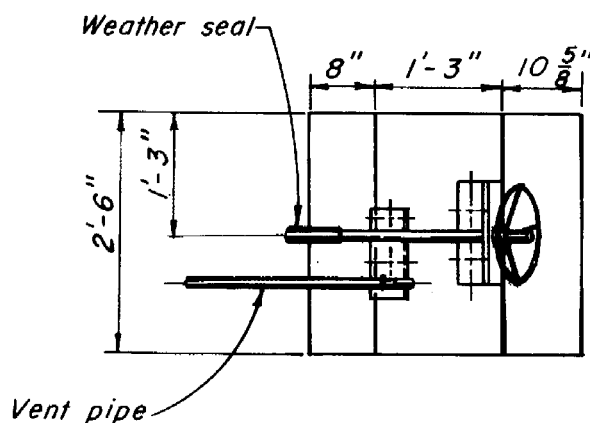
Specify bronze or cast iron lift nut

Inlet of vent pipe to consist of a screened (galv. 18 mesh) street ell and 90° ell securely fastened to the lift pedestal

FIGURE D-10  
GATE LIFT PEDESTAL  
SIZE A  
EWP Unit Portland, Oregon



SECTIONAL ELEVATION



PLAN

## GATE LIFT PEDESTAL

Note:



For lift selection and handwheel size  
refer to Figure D-1.

For handwheel bracket detail see Figure D-17

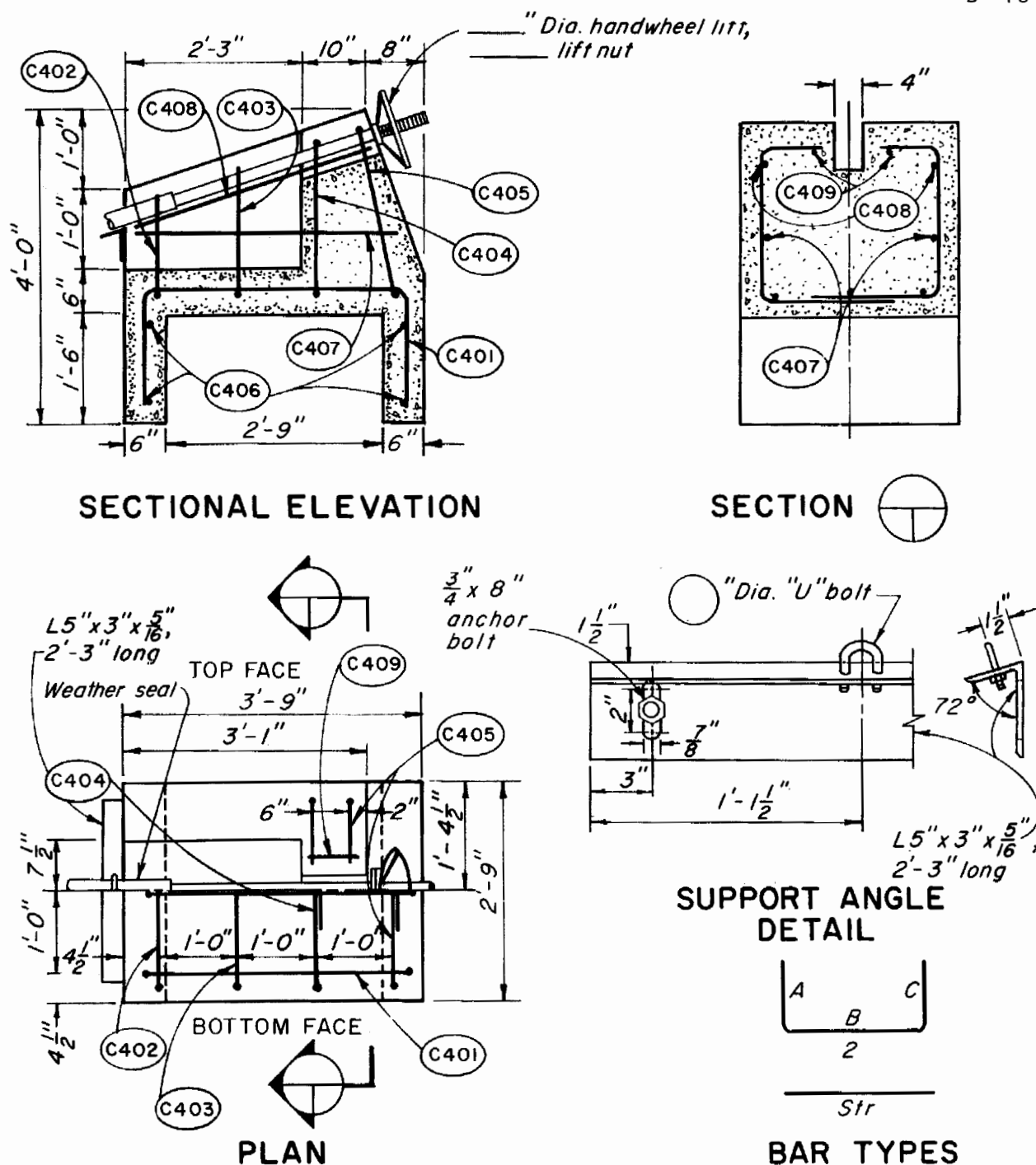
Specify bronze or cast iron lift nut

Inlet of vent pipe to consist of a screened (galv. 18 mesh)  
street ell and 90° ell securely fastened to lift pedestal

FIGURE D-11  
GATE LIFT PEDESTAL  
SIZE B

EWP Unit Portland, Oregon

7-L-20544-B



## GATE LIFT PEDESTAL



For lift selection and handwheel size refer to Figure D-1

Specify bronze or cast iron lift nut

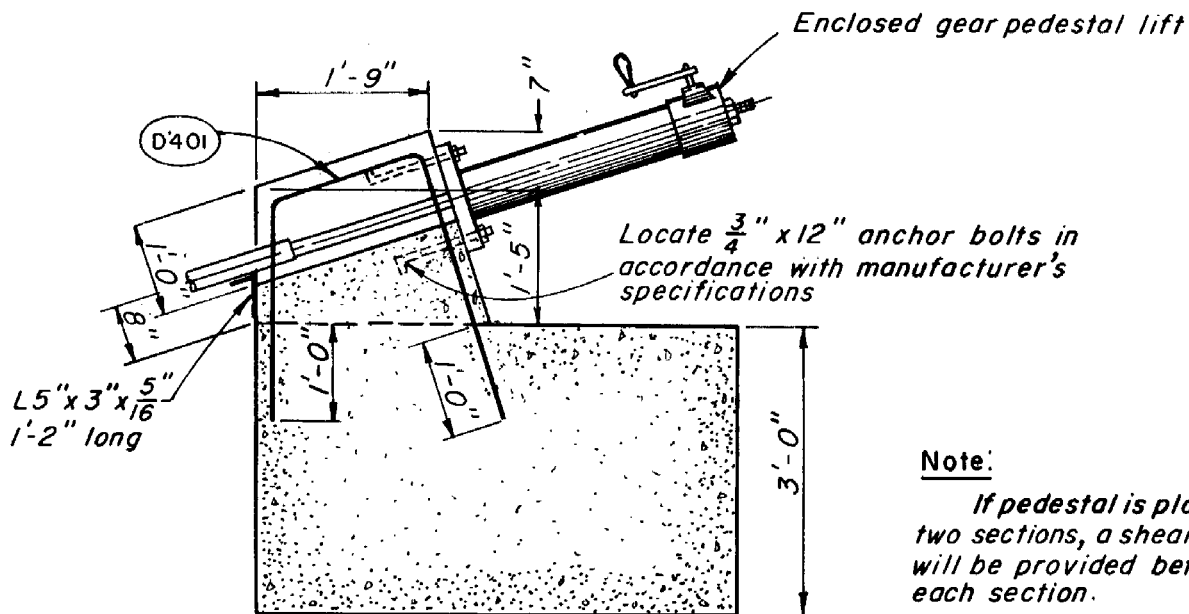
Refer to Figure D-6 for "U" bolt size

Refer to Figure D-15 or Figure D-16 for steel schedule

Vent pipe not shown. Inlet of vent pipe to consist of a screened (galv. 18 mesh) street ell and 90° ell securely fastened to the lift pedestal

FIGURE D-12  
**GATE LIFT PEDESTAL**  
SIZE C  
EWP Unit Portland, Oregon

7-L-20544-C

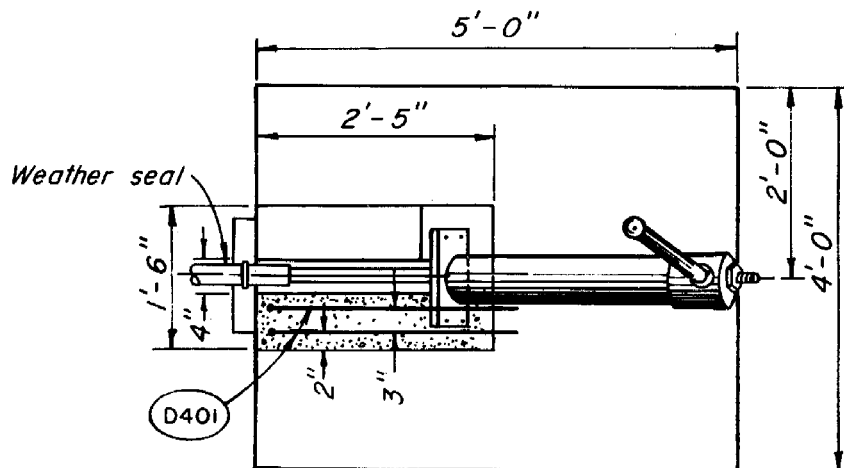


SECTIONAL ELEVATION

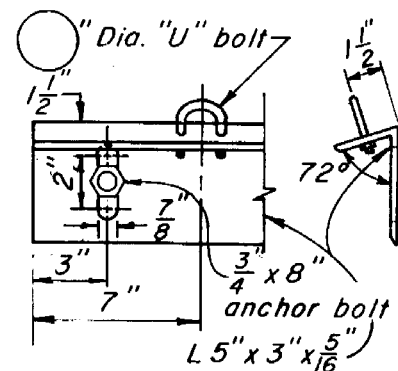
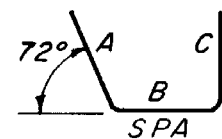
**Note:**

If pedestal is placed in two sections, a shear key will be provided between each section.

Vent pipe not shown place as required.



PLAN

SUPPORT ANGLE  
DETAIL**GATE LIFT PEDESTAL**

BAR TYPE

**Note:**

Refer to Figure D-6 for "U" bolt

For gear ratio see Figure D-1

Refer to Figure D-15 or D-16 for steel schedule

Vent pipe not shown. Inlet of vent pipe to consist of a screened (galv. 18 mesh) street ell and 90° ell securely fastened to the lift pedestal

FIGURE D-13  
**GATE LIFT PEDESTAL**

SIZE D

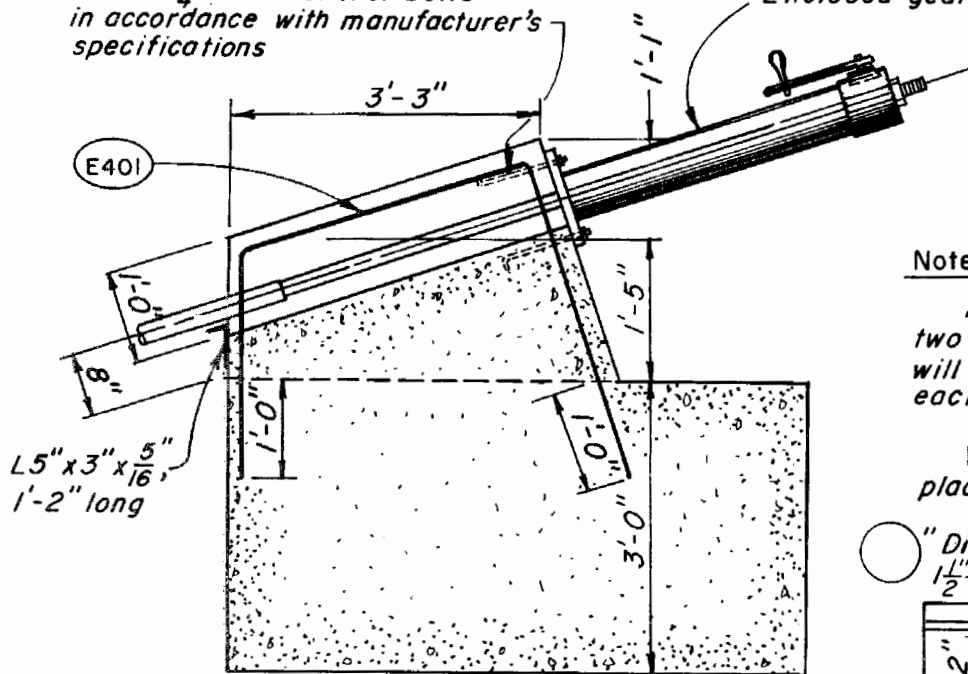
EWP Unit Portland, Oregon

7-L-20544-D

Locate  $\frac{3}{4}$  x 12 anchor bolts in accordance with manufacturer's specifications

Enclosed gear pedestal lift

D-51

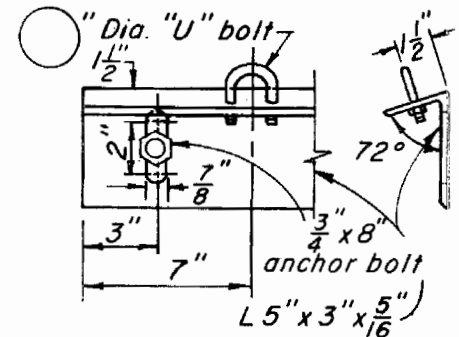


SECTIONAL ELEVATION

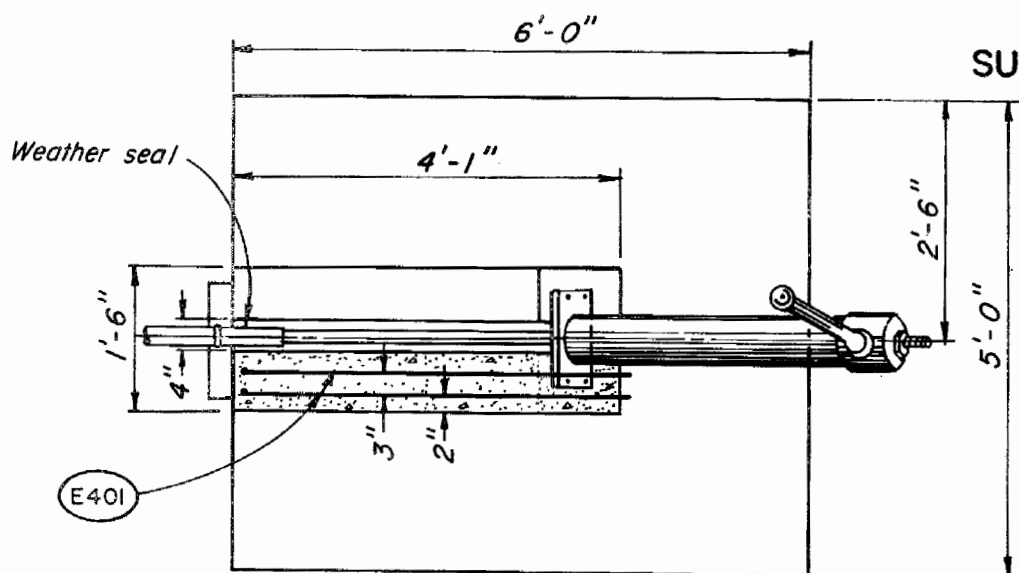
Note:

If pedestal is placed in two sections, a shear key will be provided between each section.

Vent pipe not shown, place as required.

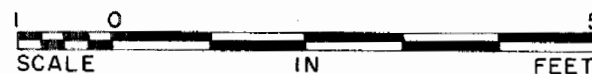


SUPPORT ANGLE  
DETAIL



PLAN

## GATE LIFT PEDESTAL

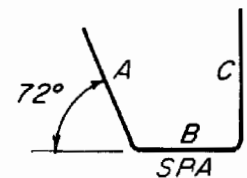


Note:

Refer to Figure D-6 for "U" bolt size  
For gear ratio see Figure D-1

Refer to Figure D-15 or D-16  
for steel schedule

Vent pipe not shown. Inlet of pipe to consist of a screened (galv. 18 mesh) street ell and 90° ell securely fastened to the lift pedestal

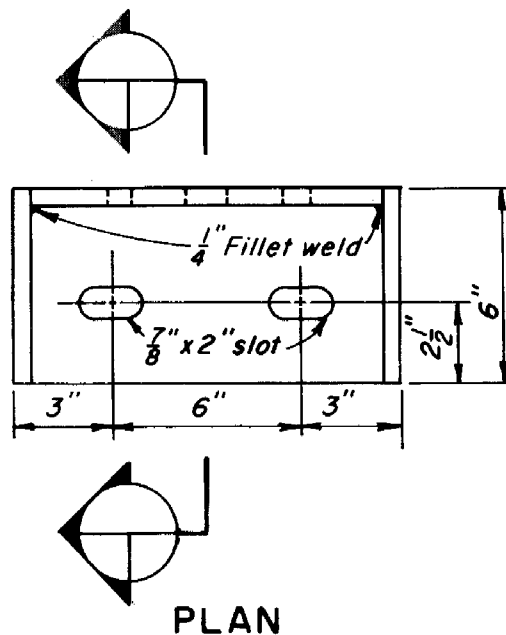
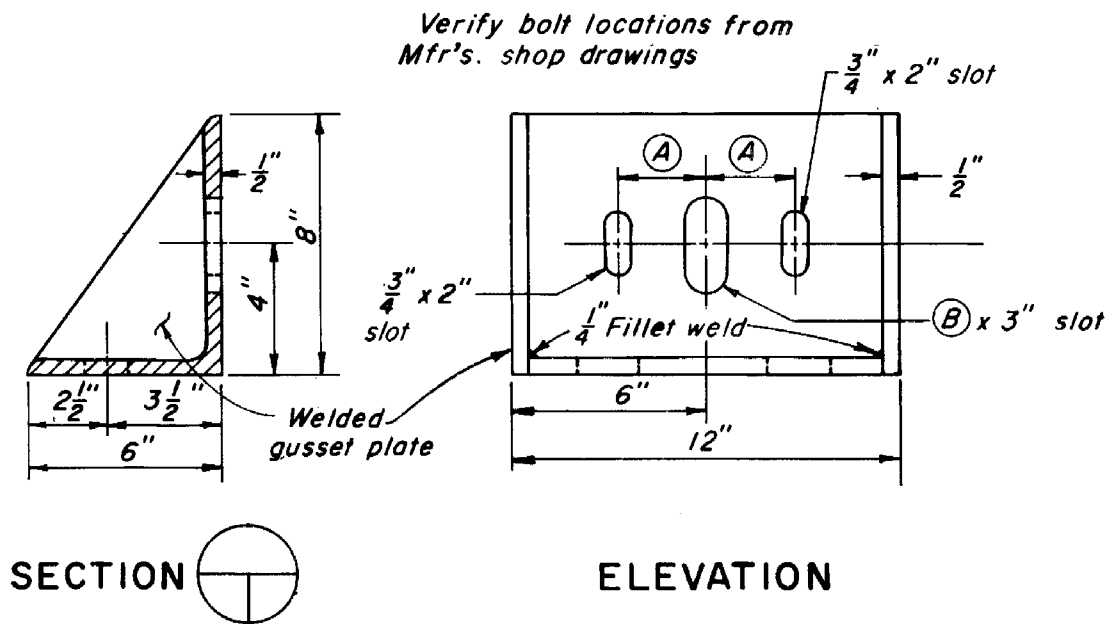


BAR TYPE

FIGURE D-14  
GATE LIFT PEDESTAL  
SIZE E

EWP Unit Portland, Oregon

7-L-20544-E



LIFT*	STEM DIA.	A	B
10	7/8"	2 3/4"	1"
14	1 1/8"	2 3/4"	1 1/4"
18	1 1/2"	3 1/2"	1 5/8"

\* Handwheel diameter-inches

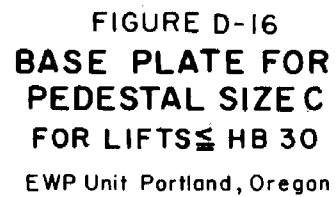


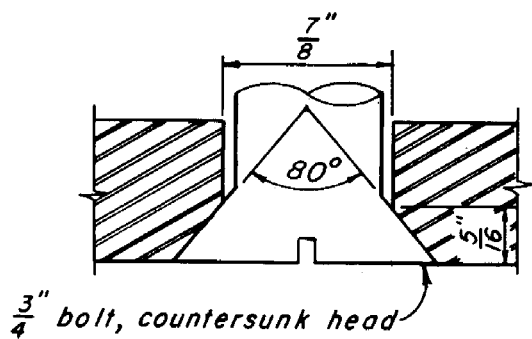
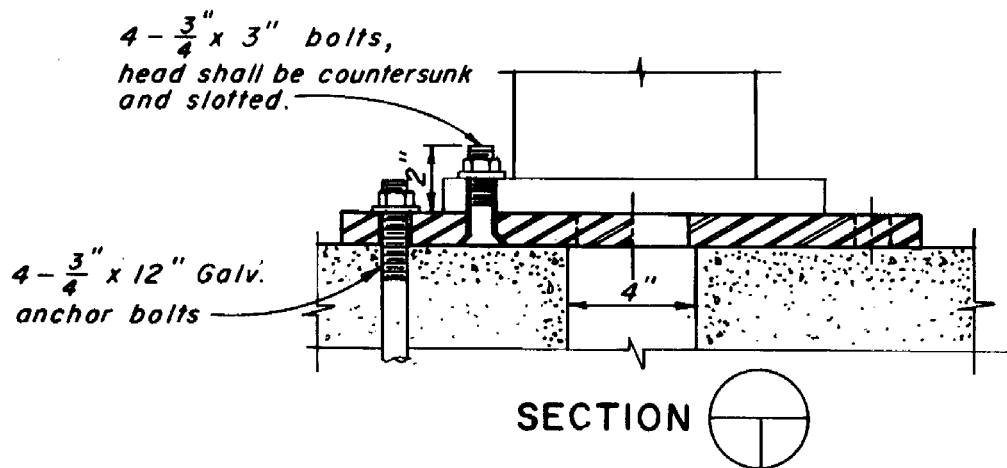
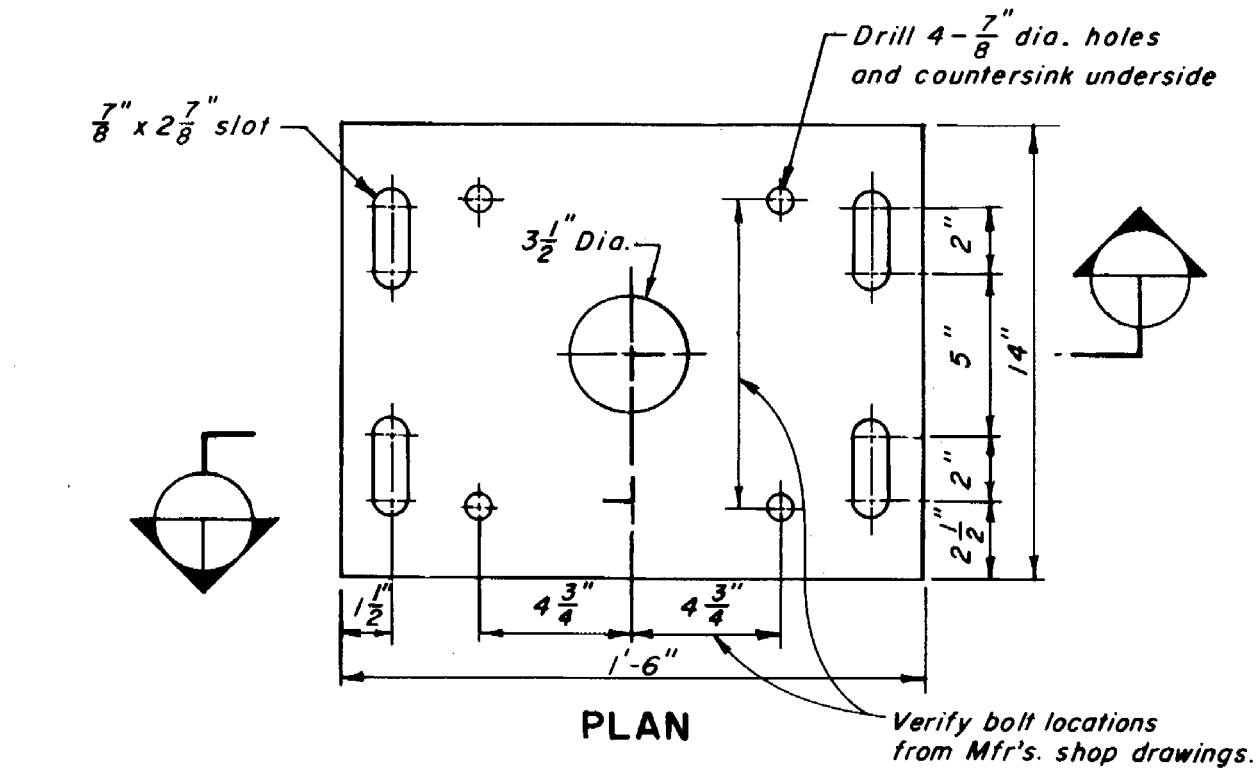
## HANDWHEEL BRACKET

FIGURE D-15  
HANDWHEEL BRACKET  
FOR GATE LIFT PEDESTAL  
SIZE A&B  
EWP Unit Portland, Oregon



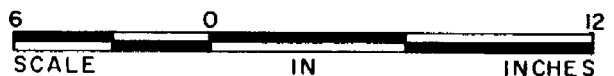
## BASE PLATE





For Pedestal D, lift with gear ratio 4:1, use  $\frac{3}{4}$ " plate.

For Pedestal E, lift with gear ratio 12:1, use 1" plate.



**COUNTERSINK DETAIL**

**BASE PLATE**

**FIGURE D-17**  
**BASE PLATE FOR**  
**GATE LIFT PEDESTALS**  
**SIZE D & E**

EWP Unit Portland, Oregon

STEEL SCHEDULE									
Location	Mark	Size	Quan.	Length	Type	A	B	C	Total Length
GATE LIFT PEDESTAL									
<i>Cutoff</i>	<i>C401</i>	<i>4</i>	<i>3</i>	<i>6'-3"</i>	<i>2</i>	<i>1'-6"</i>	<i>3'-3"</i>	<i>1'-6"</i>	<i>18'-9"</i>
<i>Sidewall</i>	<i>C402</i>	<i>4</i>	<i>1</i>	<i>4'-6"</i>	<i>2</i>	<i>1'-2"</i>	<i>2'-2"</i>	<i>1'-2"</i>	<i>4'-6"</i>
"	<i>C403</i>	<i>4</i>	<i>1</i>	<i>5'-0"</i>	<i>2</i>	<i>1'-5"</i>	<i>2'-2"</i>	<i>1'-5"</i>	<i>5'-0"</i>
"	<i>C404</i>	<i>4</i>	<i>2</i>	<i>4'-0"</i>	<i>2</i>	<i>1'-6"</i>	<i>1'-9"</i>	<i>0'-9"</i>	<i>8'-0"</i>
"	<i>C405</i>	<i>4</i>	<i>2</i>	<i>4'-3"</i>	<i>2</i>	<i>1'-6"</i>	<i>2'-0"</i>	<i>0'-9"</i>	<i>8'-6"</i>
<i>Cutoff</i>	<i>C406</i>	<i>4</i>	<i>4</i>	<i>2'-3"</i>	<i>Str</i>				<i>9'-0"</i>
<i>Sidewall</i>	<i>C407</i>	<i>4</i>	<i>2</i>	<i>3'-0"</i>	<i>Str</i>				<i>6'-0"</i>
"	<i>C408</i>	<i>4</i>	<i>2</i>	<i>2'-9"</i>	<i>Str</i>				<i>5'-6"</i>
"	<i>C408</i>	<i>4</i>	<i>2</i>	<i>0'-6"</i>	<i>Str</i>				<i>1'-0"</i>

### GATE LIFT PEDESTAL SIZE C

STEEL SCHEDULE									
Location	Mark	Size	Quan.	Length	Type	A	B	C	Total Length
GATE LIFT PEDESTAL									
	<i>D401</i>	<i>4</i>	<i>4</i>	<i>6'-9"</i>	<i>SPA</i>	<i>2'-3"</i>	<i>1'-6"</i>	<i>3'-0"</i>	<i>27'-0"</i>

### GATE LIFT PEDESTAL SIZE D

STEEL SCHEDULE									
Location	Mark	Size	Quan.	Length	Type	A	B	C	Total Length
GATE LIFT PEDESTAL									
	<i>E401</i>	<i>4</i>	<i>4</i>	<i>9'-0"</i>	<i>SPA</i>	<i>2'-5"</i>	<i>3'-1"</i>	<i>3'-6"</i>	<i>36'-0"</i>

### GATE LIFT PEDESTAL SIZE E

#### Note:

Use with Std. Drwg. 7-L-20544  
C, D, or E when construction drawings  
are to be reduced one half size.

FIGURE D-18  
GATE LIFT PEDESTAL  
STEEL SCHEDULE  
EWP Unit Portland, Oregon

STEEL SCHEDULE									
Location	Mark	Size	Quan.	Length	Type	A	B	C	Total Length
GATE LIFT PEDESTAL									
Cutoff	C 401	4	3	6'-3"	2	1'-6"	3'-3"	1'-6"	18'-9"
Sidewall	C 402	4	1	4'-6"	2	1'-2"	2'-2"	1'-2"	4'-6"
"	C 403	4	1	5'-0"	2	1'-5"	2'-2"	1'-5"	5'-0"
"	C 404	4	2	4'-0"	2	1'-6"	1'-9"	0'-9"	8'-0"
"	C 405	4	2	4'-3"	2	1'-6"	2'-0"	0'-9"	8'-6"
Cutoff	C 406	4	4	2'-3"	Str				9'-0"
Sidewall	C 407	4	2	3'-0"	Str				6'-0"
"	C 408	4	2	2'-9"	Str				5'-6"
"	C 409	4	2	0'-6"	Str				1'-0"

### GATE LIFT PEDESTAL SIZE C

STEEL SCHEDULE									
Location	Mark	Size	Quan.	Length	Type	A	B	C	Total Length
GATE LIFT PEDESTAL									
	D 401	4	4	6'-9"	SPA	2'-3"	1'-6"	3'-0"	27'-0"

### GATE LIFT PEDESTAL SIZE D

STEEL SCHEDULE									
Location	Mark	Size	Quan.	Length	Type	A	B	C	Total Length
GATE LIFT PEDESTAL									
	E 401	4	4	9'-0"	SPA	2'-5"	3'-1"	3'-6"	36'-0"

### GATE LIFT PEDESTAL SIZE E

**Note:**

Use with Std. Drwg. 7-L-20544  
C, D or E when construction drawings  
are to be reproduced full size.

FIGURE D-19  
GATE LIFT PEDESTAL  
STEEL SCHEDULE  
EWP Unit Portland, Oregon

## Typical Control Station

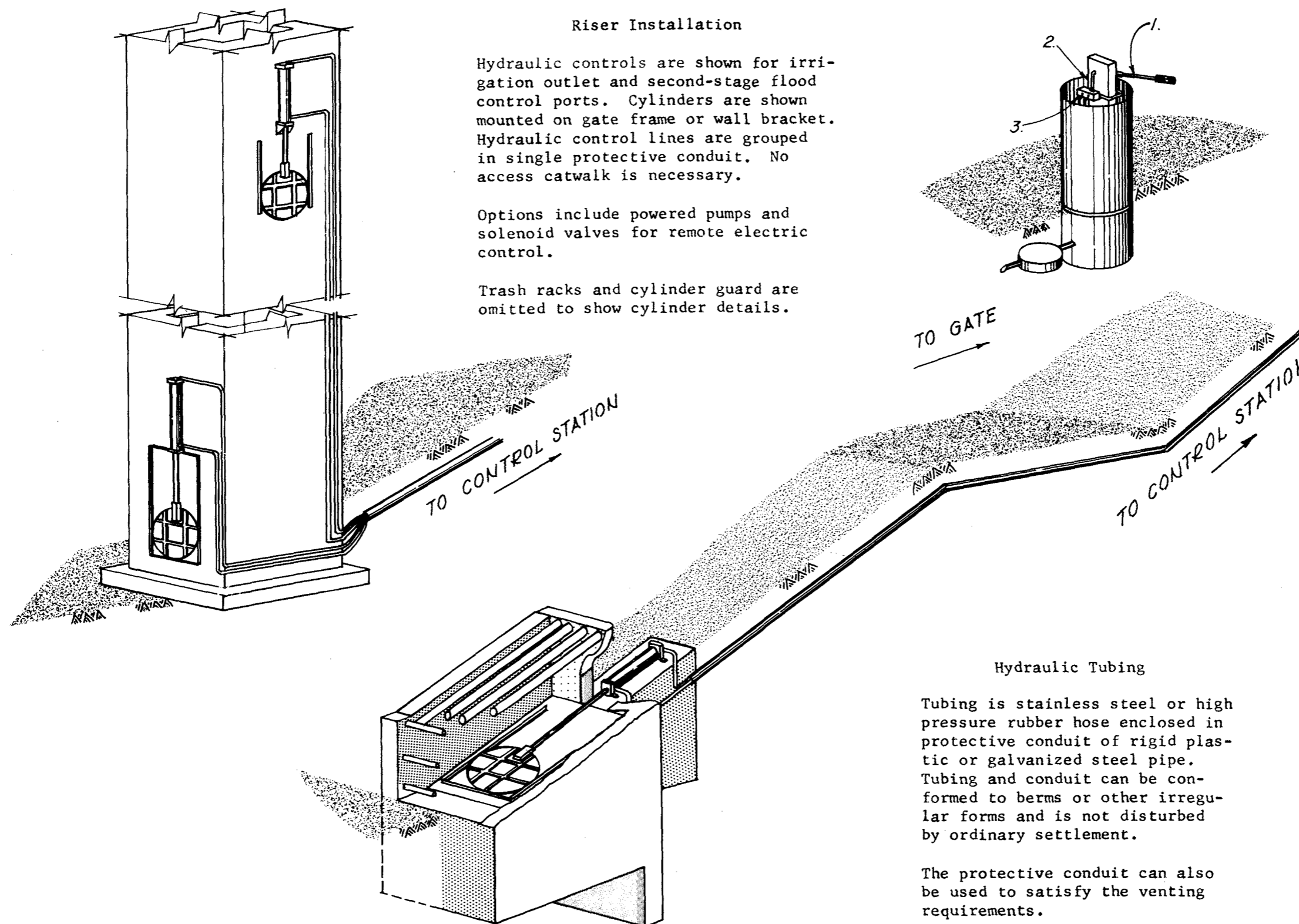
Minimum equipment includes:

1. Pump
2. Reservoir
3. 4-way Control Valve

Junction box houses connections.

The controls are shown mounted on a standard pipe section. Protection can be provided by a locking manhole cover and frame. Alternate mounts may vary from a simple post to a walk-in shed.

Controls can be located at the crest of the embankment or at a downstream measuring device.



## Riser Installation

Hydraulic controls are shown for irrigation outlet and second-stage flood control ports. Cylinders are shown mounted on gate frame or wall bracket. Hydraulic control lines are grouped in single protective conduit. No access catwalk is necessary.

Options include powered pumps and solenoid valves for remote electric control.

Trash racks and cylinder guard are omitted to show cylinder details.

## Hydraulic Tubing

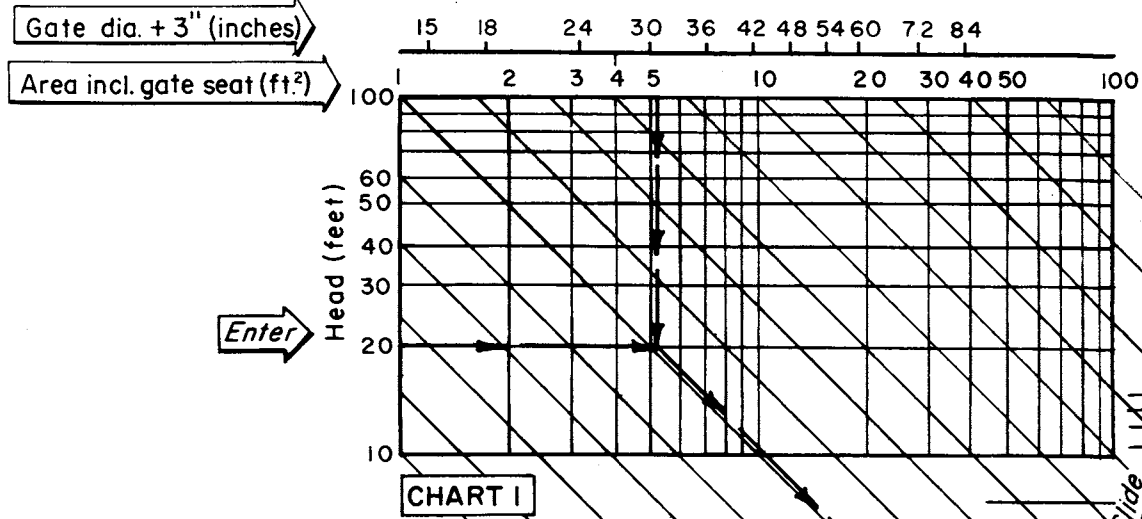
Tubing is stainless steel or high pressure rubber hose enclosed in protective conduit of rigid plastic or galvanized steel pipe. Tubing and conduit can be conformed to berms or other irregular forms and is not disturbed by ordinary settlement.

The protective conduit can also be used to satisfy the venting requirements.

## Typical Irrigation Inlet

Hydraulic cylinder is a J.I.C. Standard with stainless steel piston rod. Side lug mount is shown bolted directly to concrete surface.

FIGURE D-20  
HYDRAULIC CONTROL  
APPLICATIONS  
EWP Unit Portland, Oregon



**NOTES**

1. Cylinders are selected from J.I.C. Interchangeable Series (2000 psi operating, 3000 psi non-shock) for use at maximum pressure applied by hand pump. For use with electric or mechanical power shock must be considered.
2. Friction factor is taken as 0.7.
3. Chart 2 uses full weight of gate slide.
4. Chart 3 - Areas listed are pull stroke (cylinder area minus rod area).
5. Chart 3 - Std. indicates standard rod, O.S. indicates oversize rod.
6. Chart 3 is zoned for several cylinder bore and piston rod sizes. Colored area in each zone has an operating pressure between 2000 - 3000 psi; the rest of the zone less than 2000 psi.

**Example Problem**

**GIVEN:**

1. Outlet gate diam. (or area)  $(24 + 3)^2$  5.06 sq ft
2. Maximum head of water to C of gate 20 ft
3. Weight of gate slide (Catalog data) 200 lbs
4. Stroke =  $(24 + 4) =$  28 in
5. "L" dimension measured as shown above Chart 3 for front flange mount 36 in

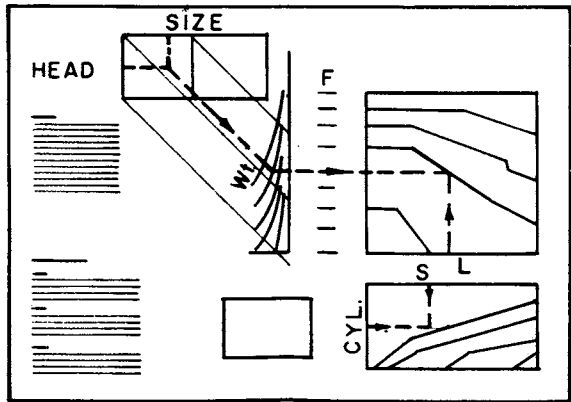
**PROCEDURE:**

Enter Chart 1 with gate size plus seat allowance and head. From intersection proceed down 45° guide line to the Gate Slide Weight, Chart 2, then horizontally to intersection with vertical line from "L" value in Chart 3. Enter Chart 4 with stroke and cylinder selection for reservoir capacity.

**FIND:**

1. Force (For design of bracket and anchorage) 4700 lbs
2. Cylinder Bore Size 2 in
3. Pressure < 3000 psi
4. Piston Rod O.S.
5. Reservoir Capacity 45 cu in

CHART 2



FLOW DIAGRAM

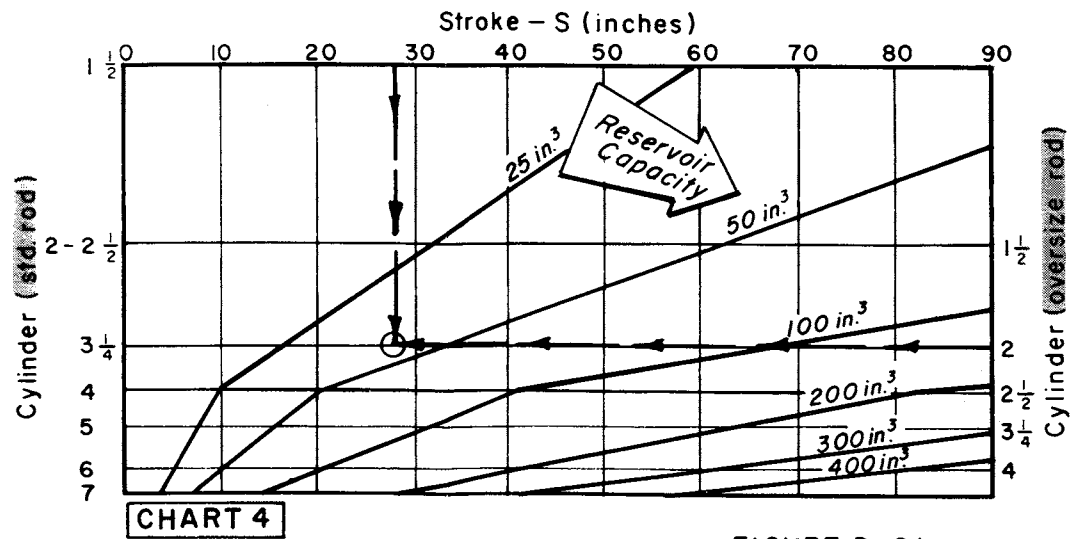
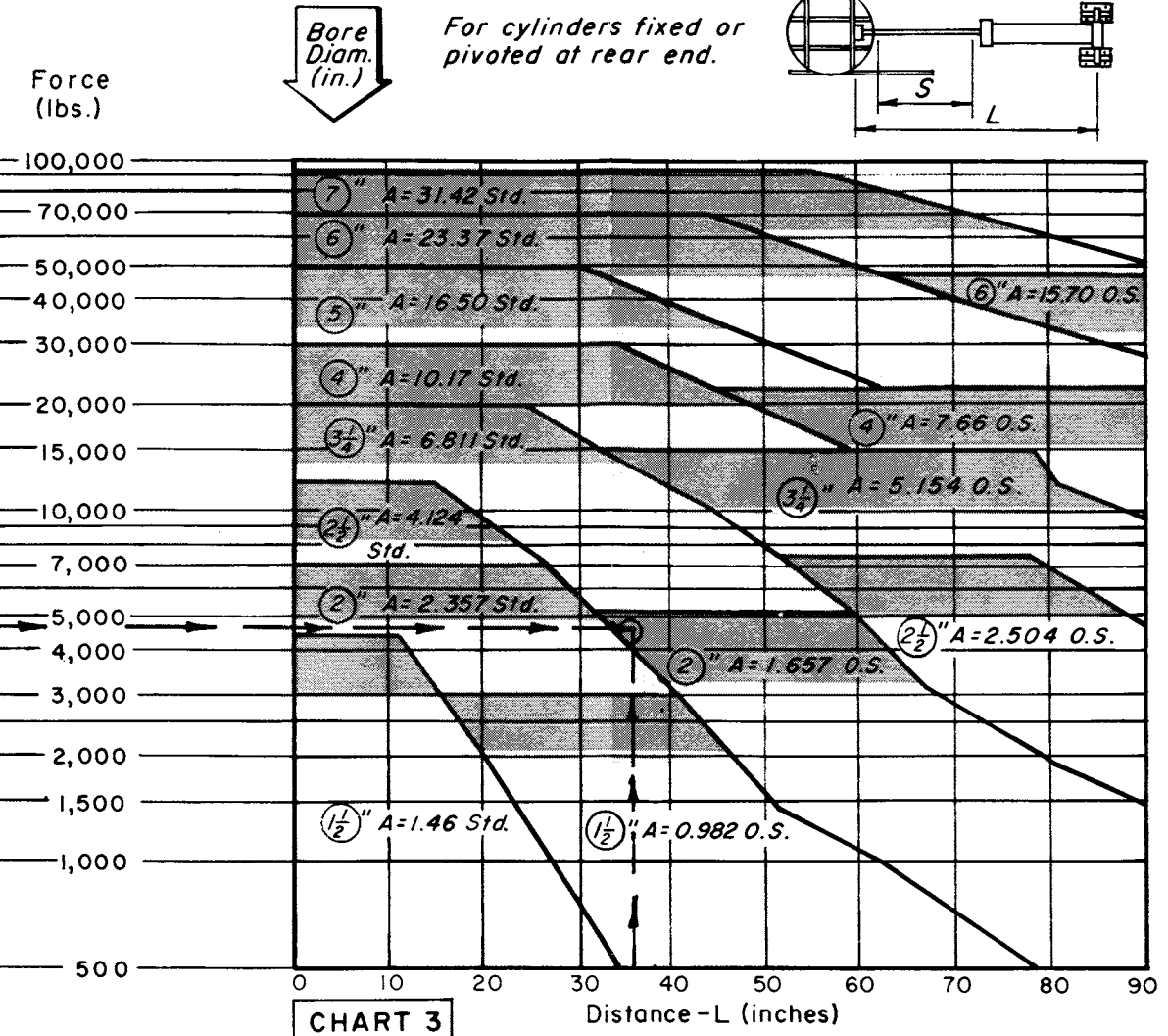


FIGURE D-21  
SELECTION CHART FOR  
HYDRAULIC CYLINDERS  
EWP Unit Portland, Oregon

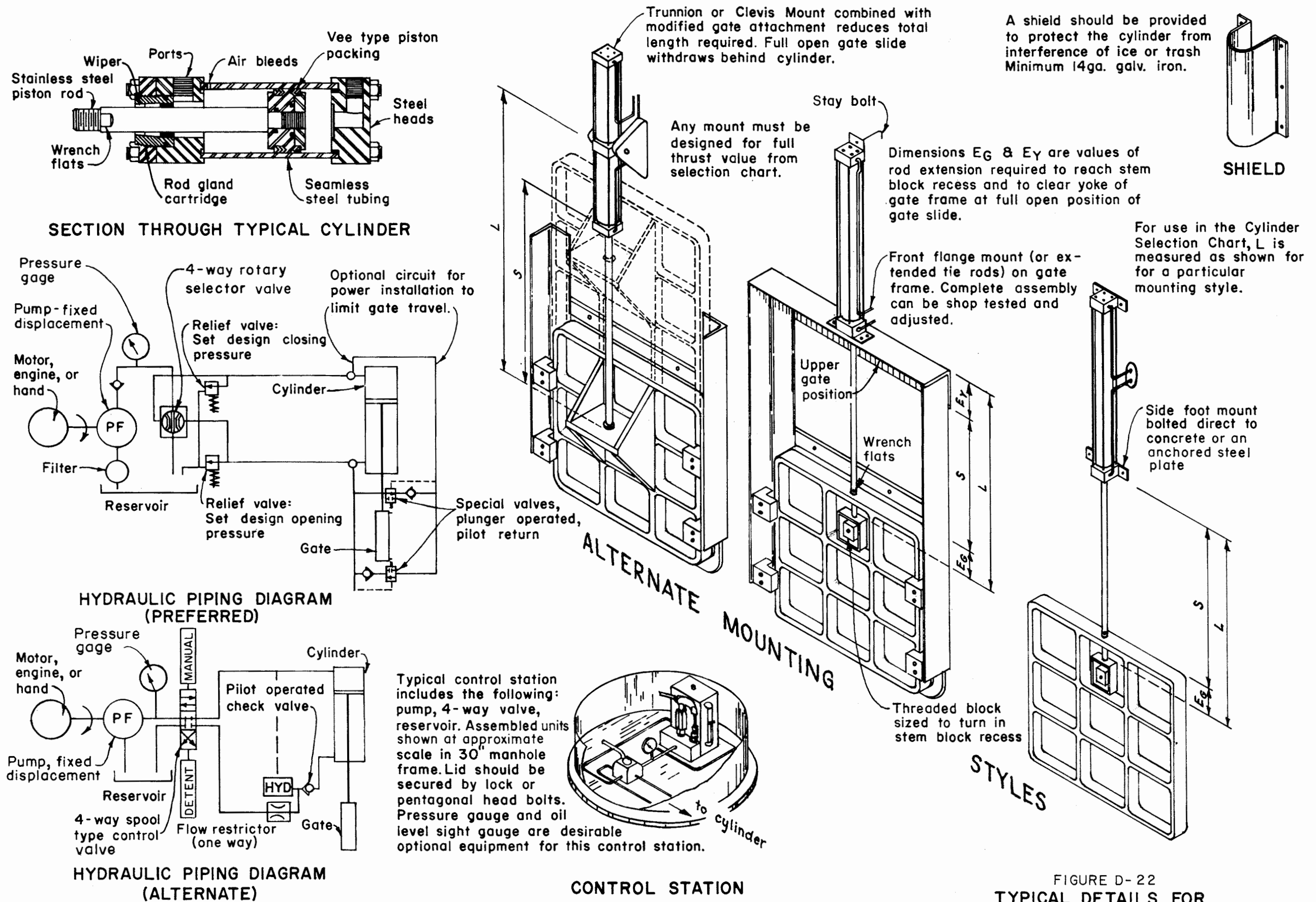
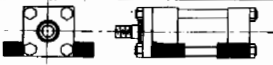
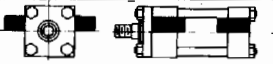
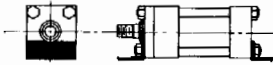
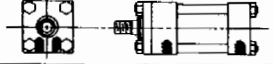
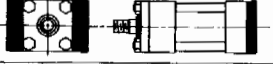

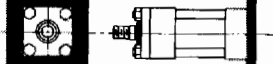











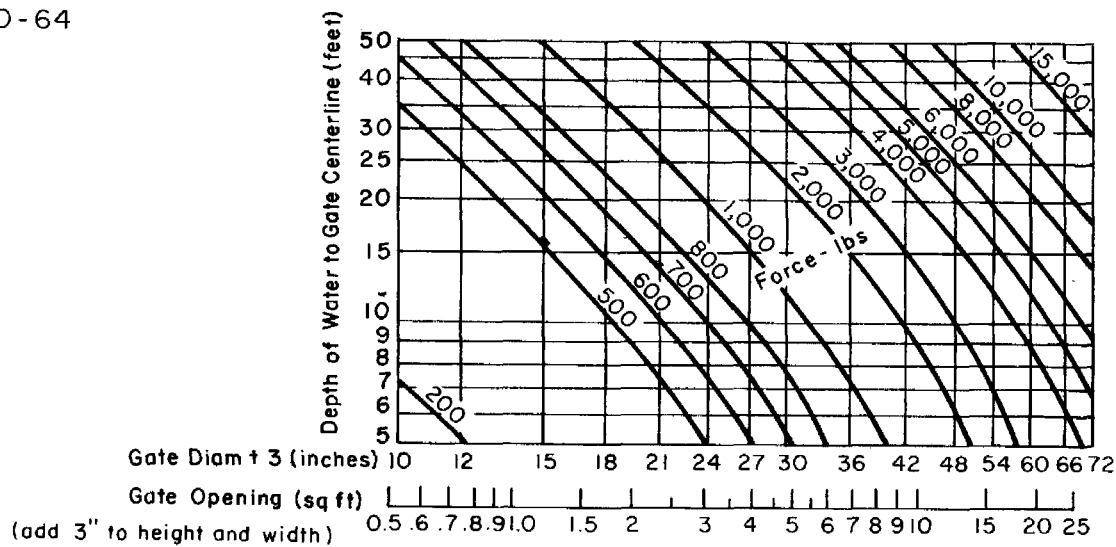
FIGURE D-22  
TYPICAL DETAILS FOR  
HYDRAULIC CYLINDER GATE CONTROLS

EWP Unit Portland, Oregon

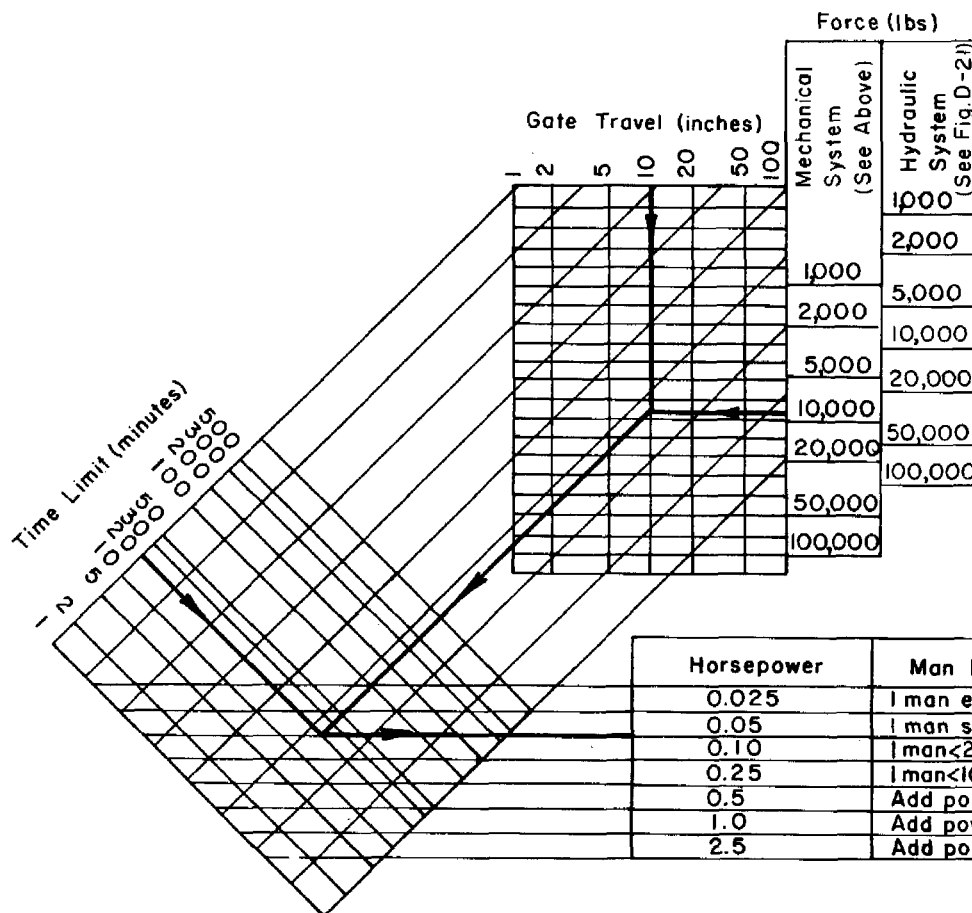
MOUNTING STYLE		CARTER	HANNIFIN	MILLER
	Side Foot Mount	CNS (Non-Cushioned) CFS (Cushioned Front End) CRS (Cushioned Rear End) CBS (Cushioned Both Ends)	C-H10	H72
	Centerline Mount	KNS (Non-Cushioned) KFS (Cushioned Front End) KRS (Cushioned Rear End) KBS (Cushioned Both Ends)	E-H10	H73
	End Foot Mount	LNS (Non-Cushioned) LFS (Cushioned Front End) LRS (Cushioned Rear End) LBS (Cushioned Both Ends)	CB-H10	—
	Side Flush Mount	FNS (Non-Cushioned) FFS (Cushioned Front End) FRS (Cushioned Rear End) FBS (Cushioned Both Ends)	F-H10	H74
	Rear Flange Mount	ANS (Non-Cushioned) AFS (Cushioned Front End) ARS (Cushioned Rear End) ABS (Cushioned Both Ends)	H-H10	H62
	Front Flange Mount	BNS (Non-Cushioned) BFS (Cushioned Front End) BRS (Cushioned Rear End) BBS (Cushioned Both Ends)	J-H10	H61
	Square Rear Flange Mount	VNS (Non-Cushioned) VFS (Cushioned Front End) VRS (Cushioned Rear End) VBS (Cushioned Both Ends)	HB-H10	H66
	Square Front Flange Mount	WNS (Non-Cushioned) WFS (Cushioned Front End) WRS (Cushioned Rear End) WBS (Cushioned Both Ends)	JB-H10	H65
	Clevis Mount	GNS (Non-Cushioned) GFS (Cushioned Front End) GRS (Cushioned Rear End) GBS (Cushioned Both Ends)	BB-H10	H84
	Front Trunnion Mount * Intermediate Trunnion Available	ENS (Non-Cushioned) EFS (Cushioned Front End) ERS (Cushioned Rear End) EBS (Cushioned Both Ends)	D-H10	H81
	Rear Trunnion Mount * Intermediate Trunnion Available	DNS (Non-Cushioned) DFS (Cushioned Front End) DRS (Cushioned Rear End) DBS (Cushioned Both Ends)	DB-H10	H82
	Tie Rods Extended Both Ends	TNS (Non-Cushioned) TFS (Cushioned Front End) TRS (Cushioned Rear End) TBS (Cushioned Both Ends)	TD-H10	H51
	Tie Rods Extended Rear End Only	YNS (Non-Cushioned) YFS (Cushioned Front End) YRS (Cushioned Rear End) YBS (Cushioned Both Ends)	TC-H10	H52
	Tie Rods Extended Front End Only	ZNS (Non-Cushioned) ZFS (Cushioned Front End) ZRS (Cushioned Rear End) ZBS (Cushioned Both Ends)	TB-H10	H53
	Basic Mount	SNS (Non-Cushioned) SFS (Cushioned Front End) SRS (Cushioned Rear End) SBS (Cushioned Both Ends)	T-H10	H50
	Double-End Construction Available in Any Mount	—DER Suffix	K Prefix	D Prefix
INTERCHANGEABLE STANDARD ROD ENDS		Male (Standard)	Style #1	Style 10 & 20
		Male (Alternate)	Style #2	Style 11
		Male (Optional)	Style #3	Style 12
		Female	Style #4	Style 3

REFERENCE: CARTER CONTROL, INC.

FIGURE D-23  
HYDRAULIC CYLINDER  
INTERCHANGE CHART  
EWP Unit Portland, Oregon



### FORCE IN MECHANICAL LIFT



### EVALUATION OF POWER REQUIREMENT

FIGURE D-24  
CONTROL OPERATION  
MANUAL vs POWER  
EWP Unit Portland, Oregon